PART I: INTRODUCTION

1. INTRODUCTION

1.1 Background of the Study

1. In the Colombo Metropolitan Region (CMR), which supports a population of 5.3 million (2001), frequent flood inundation is likely since the urbanized areas originating from the city of Colombo have been expanding in the coastal lowlands and are prone to inundation due to the difficulty of drainage. The inundation causes damage to property and infrastructures and degrades the hygienic environment of residents. Accordingly, implementation of countermeasures against inundation is a quite important subject to secure lands free from inundation for development in CMR in the future.

2. In September 1999, the Government of Sri Lanka (GOSL) requested the Government of Japan (GOJ) to undertake a study to formulate a drainage master plan. GOJ agreed to conduct the "Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka" (the Study). The scope of work was agreed between the Sri Lanka Land Reclamation and Development Corporation (SLLRDC) of the Ministry of Urban Development, Construction & Public Utilities (presently Ministry of Housing & Plantation Infrastructure) and the Japan International Cooperation Agency (JICA) on March 7, 2001.

1.2 Objectives of the Study

3. The objectives of the Study are:

   1) To formulate a master plan for storm water drainage in the Colombo Metropolitan Region,
   2) To conduct a feasibility study on priority projects identified in the master plan, and
   3) To carry out technology transfer to counterpart personnel in the course of the Study.

1.3 Study Area

4. The area for the master plan study is shown in Figure 1.1, which is a part of the Colombo Metropolitan Region. The study area is roughly divided into four drainage basins, Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin. The total catchment area comes to 830 km^2.

1.4 Priority Project for Feasibility Study

5. Based on the master plan study, the storm water drainage project for the Weras Ganga basin, a sub-catchment of the Bolgoda basin, was selected as a priority project for feasibility study. The Weras Ganga basin is shown in Figure 1.1. Its catchment area is 55.5 km^2.

1.5 Study Schedule and Activities

6. The Study was carried out over 18 months from September 2001 to February 2003 and the entire study period was divided into two phases as given below:

Phase 1 : Master Plan Study

- Preparatory Work in Japan (September 2001)
- First Field Work in Sri Lanka (September 17, 2001 to March 9, 2002)
- First Home Work in Japan (June 2002)

Phase 2 : Feasibility Study on Priority Project

- Second Field Work in Sri Lanka (July 1 to October 13, 2002)
- Second Home Work in Japan (October to November 2002)
- Third Field Work in Sri Lanka (December 15 to 22, 2002)
- Third Home Work in Japan (February 2003)

7. In the course of the Study, Progress Reports were prepared in the first and second field works, an Interim Report in the first home work, Draft Final Report in the second home work and Final Report in the third home work. All the results of the Study were explained to and discussed with Sri Lanka side at every occasion of submission, except for the Final Report, and they were concurred with by the Sri Lanka side in the Steering Committee meeting.

1.6 Technology Transfer to Counterpart Personnel

8. As one of the objectives of the Study, technology transfer was carried out in the form of on-the-job training through joint work by the team members and the counterpart personnel. Also, two workshops and one seminar were held inviting government agencies and local authorities concerned as well as counterpart personnel. In addition, occasional discussions with team members and the counterpart personnel and mini seminars on hydraulic and hydrological software (MIKE 11) used for the Study were held.

PART II: MASTER PLAN

2. PRESENT CONDITIONS OF THE STUDY AREA

2.1 Natural Conditions

Geography

9. The study area extends from Katunayake in the north to Kalutara in the south or approximately between lat. 6°36´N and lat. 7°10´N and between long. 79°50´E and long. 80°05´E. The area is located mostly in the coastal lowland. In the north, Negombo Lagoon and Muthurajawela Marsh lie in the lowland. While Bolgoda Lake North and South exist in the south. The Kelani Ganga passes through almost the center of the study area and divides the study area into two. The study area consists of marsh, lowland and hilly areas. The marshes extend in the downstream of the study area and have an elevation of 0 m to 2 m above MSL. The lowlands in the study area extend along the river course and have an elevation of 2 m to 5 m above MSL. On the other hand, the hilly areas are located at an elevation of more than 10 m above MSL.

General Geology

10. Sri Lanka is geologically related to India with which it was united as a part of the ancient southern continent of Gondawanaland. The entire island is underlain by a complex of metamorphic rocks, which is divided into Highland Series, Vijayan Series and Southwestern Series. The study area is in the Crystalline Zone with the Vijayan Series north of Colombo and the South-western Series south of Colombo. Major folds are not present in the study area, but a number of narrow folds in quartzite are present near Avissawella beyond the interior boundary of the study area. The coastal belt flat country has been formed by sand beaches, lagoon silt and clay, blown sand, and river alluvium.

Climate

11. The climate of Sri Lanka is classified as tropical monsoon, having a wet season and a short dry season. The study area is located in the southwestern quarter of the Island and classified as a wet zone.The annual climate is characterized by the Northeast Monsoon from December through February and the Southwest Monsoon from May through September. The dry season is brought about by the Northeast Monsoon and the wet season by the Southwest Monsoon. The average annual rainfall amounts to some 2,400 mm. There are two peaks of monthly rainfall in a year, May and October. The mean daily maximum temperature ranges from 31.1 ^{o}C in April to 29.3 ^{o}C in August,

while the mean daily minimum temperature ranges from 25.3 ^{o}C in May to 22.2 ^{o}C in January.

2.2 Socio-economy

Population and Economic Condition

12. The study area (830 km^2) covers the economic center of CMR and administratively belongs to Colombo District, Gampaha District, and Kalutara District. The population of the study area in 2001 was estimated at 3.4 million or 64.4% of the total population of the Western Province. The Western Province is one of the most highly populated areas in Sri Lanka.

13. Gross Domestic Product (GDP) of Sri Lanka in 2000 was Rs. 857 billion and had been expanding throughout the 1990s with an annual average growth rate of 5.3%. The economic growth for the year 2001 was slower than expected due to droughts and high prices for oil for power generation.

14. The Colombo Metropolitan Region plays a major role in the economic activities in Sri Lanka by producing 43% of GDP or Rs. 370 billion in 2001. The manufacturing activities are particularly high in the Western Province. The manufacturing output of the Colombo Metropolitan Region is about 70% of the national manufacturing GDP. Average monthly household income in the study area is Rs. 9,230, which is higher than the national average of Rs. 6,480.

Public Finance

15. National fiscal operation for the year 2000 shows revenue of Rs. 211 billion and expenditure of Rs. 336 billion (of which Rs. 81 billion is a capital expenditure). It resulted in the fiscal deficit of Rs. 125 billion. The cumulative government debt in 2000 reached 97% of GDP or Rs.1,219 billion and continues to increase. The fiscal condition is expected to improve after the year 2004 when the national economy will recover and payment of short-term loans will be completed.

16. Budget allocation is determined based on the necessity, urgency and the impact to the economy. It is largely classified into ordinary costs, costs for foreign funded projects, O&M costs of the existing facilities and costs for domestically funded projects. The projects funded by foreign donors are given priority among the capital expenditures because of the low cost of borrowing and funding to the projects focusing on infrastructure development which matches the interest of the Sri Lanka government.

Financing for Storm Water Drainage Projects

17. The budget for drainage projects is transferred from the central government to SLLRDC as "capital transfers to public corporations", which include construction costs and O&M costs. SLLRDC, one of the largest receivers of the capital transfer payments among public corporations, received Rs. 2,142 million in 2000 which is 0.6% of the government expenditure or 3.2% of the capital expenditure (17.8% share among the public corporations). Of the amount received, Rs. 35 million is allocated for maintenance of canals and Rs. 2,107 million for construction.

2.3 Present Land Use

18. The present land use pattern of the study area is shown in Figure 2.1. Within the study area, the land use is categorized as urban area, semi-urban area, paddy land, marsh area, water bodies and others such as rural area, forest and grassland. Their areas are 4,929 ha (6.1%), 5,922 ha (7.3%), 14,229 ha (17.6%), 2,016 ha (2.5%), 1,508 ha (1.9%) and 52,112 ha (64.6%), respectively. The spatial distribution of each land use category reveals that the urban area is concentrated mainly in the Greater Colombo basin, while the marsh area is concentrated in the Ja Ela basin.

2.4 Natural and Social Environment

Natural Environment

19. Environmental features of the study area are represented by studded marshes with a connecting water system in the urban area. The study area is located in the southwestern coastal area of the Island and climatically belongs to the wet zone where much of Sri Lanka's biodiversity is concentrated. Lowlands, where the lands are mostly abandoned paddies and vacant lands, form marshes and marshy lands. Among the marshes in the study area, Muthurajawela Marsh (3,068 ha) and Bellanwila-Attidiya Marsh (372 ha) are protected areas and good birding sites for endemic and migratory birds in Sri Lanka.

20. A list of the protected areas legally constituted includes Bellanwila-Attidiya Marsh, Sri Jayawardenapura Kotte Marsh (449 ha), and Negombo Lagoon complex (1,285 ha) shown in Figure 2.2. In addition, a list of wetlands considered to be of national importance includes Beira Lake, Bolgoda Lake, Colombo Breakwaters and Colombo flood retention area located in the study area. The environmental conditions in the marshes are poor due to solid waste dumping, inflow of polluted water, unauthorized settlement and unplanned reclamation.

21. Surface water pollution is a serious problem in the study area. Pollution of urban water bodies by domestic and industrial wastewater causes environmental problems as well

as health hazards such as waterborne disease. The most serious water pollution problems are observed in the canals and lakes located in the downstream areas. Overflow of septic tanks and ingress of sewage into the drainage canals is commonly observed in the study area during heavy rains.

22. Colombo MC is the only local authority to have a piped sewerage system. The sewerage system is a combined sewer system to carry both sewage and rain water and discharges the untreated wastewater to the sea through two outfalls. It is reported that 60% of the sewers are overloaded and the system frequently collapses due to aging and poor maintenance. The overloading of the system results in overflow of sewage into the drainage canals.

Social Environment

23. The urban settlements denied of basic urban services and having poor quality services or socially unacceptable housing and living conditions are referred to as Under-Served Settlements (USS). The USS population was 17% of the total population of the Colombo Metropolitan Region or 783,000 persons in 1998. The USS is classified into several types such as slums, shanty settlements, old low income flats, relocated housing, old deteriorated quarters, unplanned permanent dwellings, walkup apartments and suburban housing estates. Among them, the slums (71% of USS) and shanty settlements (12% of USS) make up the majority.

24. According to the Community Inventory Survey in the Study (Figure 2.3), about one million persons are living in the settlements affected by flood or storm water. Half of them live in the Greater Colombo basin. There are 62,800 poor households or 30 % of the surveyed households, of which monthly income is less than Rs. 3,000. The number of poor households is larger in the Greater Colombo basin (26,900 households) and Bolgoda basin (22,300 households). The number of houses affected by flood or storm water is 27,600 or 13% of the surveyed houses. Out of them, 14,600 houses are located in the Greater Colombo basin.

25. The number of households living in and around the proposed storm water drainage project areas is roughly estimated at about 60,000 households (312,000 persons). This population would potentially be directly affected by the proposed projects. About 5,600 households will be illegal occupants. The households under the poverty line (Rs. 3,000/month) are estimated at 18,600. The houses located in the riparian lands are counted as 3,500 in total for the four basins. They might be subject to relocation due to the proposed projects. The houses frequently inundated during rainy season are estimated at 8,800 in the proposed project areas. They might be beneficiaries from the proposed projects.

2.5 Storm Water Drainage

Drainage Basins

26. The study area is divided into the following drainage basins as shown in Figure 1.1. Among them, Ja Ela basin, Kalu Oya basin, Greater Colombo basin and Bolgoda basin are subject to the Study.

Basin	Basin Area (km^2)	Study Area (km^2)
Attanagalu Oya (Ja Ela)	860	173
Kalu Oya	58	58
Kelani Ganga	2,292	89
Greater Colombo	85	85
Bolgoda	394	394
Others	-	31
Total	-	830

Note: Ja Ela basin is a part of Attanagalu Oya basin.

Storm Water Drainage Projects in the Past

27. *Greater Colombo Flood Control and Environmental Improvement Project (GCFC&EIP) - Phase I*: The main canal system in and around the city of Colombo was improved by this project. The project, with an area of 85 km^2, as shown in Figure 2.3 covers a major part of the Colombo MC and some parts of the Sri Jayawardenapura Kotte MC and the Dehiwela - Mount Lavinia MC. The project was implemented from 1992 to 1998. The total length of main drainage canals improved by this project is 44 km for the drainage area of 85 km^2.

28. *Greater Colombo Flood Control and Environment Improvement Project (GCFC&EIP) - Phase II:* This project focused on urgent solutions for frequent local inundation and therefore comprised rehabilitation and augmentation of trunk drains and parts of the secondary drains connecting to the trunk drains. The project consisted of 5 schemes, Torrington West Scheme, Dematagoda Scheme, St. Sebastian-2 Scheme, Serpentine Canal Scheme and Unity Place Scheme as shown in Figure 2.3. The project was implemented from 1998 to 2001. The total length of drainage canals improved by this project is 7 km for the drainage area of 560 ha.

On-going Drainage Projects and Existing Plan

29. *Greater Colombo Flood Control and Environment Improvement Project (GCFC&EIP) - Phase III*: The Dehiwela - Mount Lavinia MC area has already been urbanized, but the storm water drainage system has not been satisfactorily provided. This project covers Kawdana Scheme and Attidiya Scheme shown in Figure 2.4. The construction work consists of box culverts, flumes, earth canals, bridges, etc. The total

length of drainage canals improved by this project is about 40 km for the drainage area of 522 ha. The project is scheduled to be completed by July 2004.

30. *Lunawa Lake Environment Improvement and Community Development Project*: This project will be composed of two components. One is the storm water drainage improvement in the area shown in Figure 2.3, consisting of drainage works, Lunawa Lake dredging work, resettlement site construction and O&M equipment supply. The other is the community development consisting of resettlement and up-grading of under-served settlements. The total length of the drains to be improved is about 87 km and the drainage area is 615 ha. The project will be implemented soon.

Inundation Areas

31. According to the flood damage survey carried out in the Study, 394 locations of inundation areas were identified within the study area as shown in Figure 2.5. Their distribution by basin and annual flood damages estimates are as follows:

Basin	No. of Inundation Areas	No. of Questionnaires	Annual Flood Damage Estimated (million Rs.)
Ja Ela	60	129	509
Kalu Oya	45	104	329
Greater Colombo	148	441	549
Bolgoda	141	334	370
Study Area	394	1,008	1,757

Frequency of Inundation

32. Frequency of inundation was surveyed distinguishing between outside and inside buildings. The results are summarized as follows:

(Unit: times/year)

Inundation	Ja Ela	Kalu Oya	Greater Colombo	Bolgoda	Study Area
Outside buildings	2.9	3.3	5.0	4.1	4.3
Inside buildings	1.7	2.6	3.8	2.9	3.1

Duration of Inundation

33. Duration of inundation indicates different characteristics by basin as presented below. Duration of 7 days or more is dominant in the Ja Ela basin and Kalu Oya basin. The majority of the durations are of one day or less in the Greater Colombo basin and Bolgoda basin, reflecting the characteristics of inundation in urbanized areas. The average and maximum durations are summarized as follows:

(Unit: days/flood)

Inundation	Ja Ela	Kalu Oya	Greater Colombo	Bolgoda	Study Area
Average	5.7	5.1	1.4	2.6	2.7
Maximum	9.3	9.5	3.1	5.2	5.3

Source: Flood Damage Survey in 2001, JICA Study Team

Existing Problems on Storm Water Drainage

34. Based on the natural characteristics of the present drainage systems and the results of the flood damage survey, the major causes of flooding in the respective basins are classified into the following:

Basin	Causes of Flooding
Ja Ela Basin	• Overflow from main streams such as Attanagalu Oya, Urwal Oya, Dandugam Oya and Ja Ela • Natural drainage difficulty in lowland surrounding Muthurajawela Marsh • Lack of storm water drainage system for draining storm water runoff to the main streams or Muthurajawela Marsh
Kalu Oya Basin	• Natural drainage difficulty from Kalu Oya and Old Negombo Canal to Kelani Ganga • Lack of storm water drainage system for draining storm water runoff to the main streams such as Kalu Oya and Old Negombo Canal • Decrease of marsh and surrounding lowland functioning as storm water retention area due to land filling
Greater Colombo Basin	• Deterioration and under-capacity of existing urban drainage systems • Uncontrolled urbanization of unprotected area under the Kelani Ganga Flood Protection Scheme
Bolgoda Basin	• Lack of storm water drainage system for draining storm water runoff to the main streams • Natural drainage difficulty in lowland surrounding the downstream water system

Estimated Flood Damage

35. Based on the results of the inundation analysis and assessment of direct and indirect flood damages, the amount of annual flood damage under the present condition is estimated at Rs. 1,757 million/year for the entire study area as follows:

Sub-basin	Estimated Extent of Inundation Area by Return Period (ha)					Annual Flood Damage (million Rs.)
	2-year	5-year	10-year	25-year	50-year	
Ja Ela	1,113	1,609	1,938	2,755	3,390	509
Kalu Oya	283	384	449	496	558	329
Greater Colombo	153	288	408	581	774	549
Bolgoda	2,419	2,929	3,278	3,645	3,913	370
Study Area	3,968	5,210	6,073	7,477	8,635	1,757

2.6 Outfall

36. There are nine estuaries, as shown in Figure 2.6, in the study area that function as outfalls for storm water drainage. Among them, the Dehiwala outfall, Lunawa Lake outfall and Talpityia outfall have been facing a problem of clogging as of November 2001. From the viewpoint of storm water drainage, the outfall of Dehiwela canal and Lunawa Lake has to be kept open. Talpityia outfall is opened by manpower when a severe flood occurs.

37. For the Dehiwala canal outfall, two groins were recently constructed at the outfall aiming at keeping the outfall open and also one groin was provided with Wellawatta outfall for beach erosion protection. The effect of the Dehiwala groins is under monitoring, but it is tentatively observed that the Wellawatta outfall is affected and clogged during dry season although the Dehiwala outfall has been opened. The Lunawa Lake outfall is maintained by periodical excavation by manpower.

2.7 Institution and Organization

Present Institutional Setting Related to Storm Water Drainage Works

38. The administrative structure in Sri Lanka is as shown in Figure 2.7. For the planning, construction and operation and maintenance (O&M) of the storm water drainage projects, a lot of government agencies are related. The major agencies are SLLRDC, the Irrigation Department, Provincial Irrigation Department and local authorities as implementation agencies. The Urban Development Authority and Agrarian Development Department are responsible for land use and regulation, the Ministry of Land, Under Settlement Improvement Program and the Urban Housing Division are responsible for land acquisition and resettlement. The Central Environmental Authority is a regulatory agency.

Present Organization and System for O&M Works

39. The organizations responsible for operation and maintenance of storm water drainage facilities, except large-scale rivers, are SLLRDC and local authorities. SLLRDC is a central government agency and responsible for O&M of the storm water drainage facilities in the declared areas. On the other hand, local authorities such as MC, UC and PS are responsible for O&M of the storm water drainage facilities in their administrative areas. The organization charts of SLLRDC are shown in Figures 2.8 and 2.9.

Issues and Constraints

40. Examining the present institutional and legislative arrangements for the storm water drainage sector, the following are considered as issues and constraints to be settled for smooth and sustainable implementation of the storm water drainage projects in the study area.

1) Unclear responsibilities among the government agencies for storm water drainage works such as Irrigation Department, SLLRDC, Local Authorities, Road Development Authorities, etc.
2) Lack of authorized land use plans at national and local levels to clearly demarcate storm water retention areas to be conserved
3) Malfunction of the regulating system of lowland development to avoid illegal or unauthorized filling of lowlands
4) Insufficient resources for storm water drainage works such as human resources, budget and equipment.

2.8 Foreign Aid

41. Foreign aid plays an important role in implementing projects in Sri Lanka. More than 30 donors of DAC nations and multilateral agencies have been contributing their assets to Sri Lanka with the annual average commitments of Rs. 55.3 billion for the period 1995 - 2000. The number of donors that support the storm water drainage projects is limited. Japan is a main donor that provided Rs. 15.9 billion of funds for the drainage projects. Some small-scale drainage projects are implemented under the urban or rural development scheme such as the Urban Development and Low Income Housing Project funded by ADB.

3. HYDROLOGICAL ANALYSIS

Rainfall Analysis

42. Based on the daily rainfall data of 14 rainfall gauging stations in and around the study area, which are operated by the Department of Meteorology, the probable annual maximum daily rainfalls are estimated by basin and return period as follows:

Return Period (years)	Probable 1-Day Rainfall (mm)			
	Attanagalu Oya (800 km^2)	Kalu Oya (58 km^2)	Greater Colombo (85 km^2)	Bolgoda (394 km^2)
2	102.8	129.7	117.3	103.2
5	134.5	184.2	175.7	137.0
10	155.9	220.3	214.3	159.7
25	182.8	266.0	269.6	188.3
50	202.8	299.8	320.1	209.6

43. A rainfall pattern is determined based on three rainfall stations that have hourly data. The duration of rainfall in the study area is mostly less than one day and one rainfall event has two to three heavy rainfalls. Among the rainfall events in the past, the rainfall that occurred in April 1999 was selected as a design rainfall pattern with a duration of one day for the entire study area.

Flood Runoff and Inundation Analyses

44. Using the software, MIKE 11, widely used for modeling of hydrological and hydraulic systems, flood runoff and inundation models in the study area were constructed and a simulation was carried out. The probable peak runoff discharges under present conditions are estimated at the most downstream base points of the respective basins as follows:

Return Period (years)	Probable Peak Runoff (m^3/sec)			
	Attanagalu Oya (800 km^2)	Kalu Oya (58 km^2)	Greater Colombo (85 km^2)	Bolgoda (394 km^2)
2	104.9	2.4	31.1	105.6
5	156.5	3.2	55.9	116.0
10	192.0	12.9	74.5	124.1
25	235.0	17.6	103.4	135.0
50	266.4	21.0	132.2	143.5

4. FORMULATION OF MASTER PLAN

4.1 Socio-economic Framework for Planning

45. The future socio-economic conditions in the study area have been projected in the Colombo Metropolitan Regional Structure Plan (CMRSP), targeting the year 2010. The socio-economic framework to be applied to the present storm water drainage master plan is set based on CMRSP, so that the target year for the present storm water drainage plan is also set at 2010.

46. The population in the study area is estimated from the projected population of the Colombo Metropolitan Region (CMR) in CMRSP and the area coverage of the study area in CMR. The population of CMR in 2010 is projected to be 6.5 million applying the growth rate of 2.4% in CMRSP. The population of the study area is estimated at 4.18 million.

47. The economic framework of the study area is projected based on the characteristics of economic activities in the agriculture, industry and service sectors in the study area and the national trend referring to 'Vision 2010 Sri Lanka'. The average GRDP growth rate of the study area is estimated at 7.2% up to 2005 and 7.9% from 2005 to 2010. The

GRDP of the study area in 2010 is estimated at Rs. 612 billion. The share of agriculture is 2%, industry 50% and service 48%.

4.2 Future Land Use

48. The future land use pattern is shown in Figure 4.1. It is forecasted by applying the driving forces of the land use change such as future development, urban sprawl, etc. Within the study area, the major land use categories relating to the Study are urban area, semi-urban area, paddy land, marsh area, water bodies and others such as forest and grassland. Their areas are 10,735 ha (13.3%), 16,950 ha (21.0%), 13,480 ha (16.7%), 1,937 ha (2.4%), 1,533 ha (1.9%) and 36,081 ha (44.7%), respectively.

49. The urbanization will progress rapidly in the Kalu Oya and Kelani River basins. The built-up area of urban and semi-urban areas is supposed to increase in the Kalu Oya basin and northern part of Bolgoda basin (Weras Ganga sub-basin). The paddy lands will decrease in the Ja Ela and Kalu Oya basins. The marsh lands will sharply decrease in the Kalu Oya basin.

4.3 Planning Scale and Comprehensive Storm Water Drainage Plan

50. A guideline for storm water drainage planning scale has not been prepared yet in Sri Lanka. For the present Study, the guideline used in Japan is referred to. The planning scale is one of the fundamental subjects to determine a policy of flood control for the future and it should be decided by the government. For the decision, three options of planning scales of 50-year, 25-year and 10-year return periods are studied.

51. The Study recommends applying a planning scale of a 50-year return period to main streams and major tributaries considering the importance of the study area in the Colombo Metropolitan Region. On the other hand, a planning scale of a 5 to 10-year return period is proposed for the urban drainage with small catchments.

52. The present Study intends to formulate a comprehensive storm water drainage plan and it includes the following components.

1) Structural measures
2) Non-structural measures
3) Institutional development plan
4) Operation and maintenance plan
5) Human resources development plan

4.4 Storm Water Drainage Plan for Ja Ela Basin

Basic Principle for Planning

53. The future land use projection for the study area indicates that the urbanization in the Ja Ela basin will proceed mainly along the Negombo Road and at a few inland locations such as Gampaha and Minuwangoda and most of the basin will remain unchanged. The significant increase of storm water runoff of the main streams will not be expected within the time scale ending in the target year 2010. The storm water drainage plan for the Ja Ela basin therefore aims at protecting the future urbanized areas along the Negombo Road by means of improvement of the downstream reaches of Dandugam Oya and Ja Ela, conservation of the paddy lands in the middle reaches as a storm water retention area and conservation of the Muthurajawela Marsh as a flood plain.

Structural Measures

54. For the comparative study, the following alternative cases are set by combining the conceivable measures shown in Figure 4.2 for the planning scale of 50-year return period.

Case	Measures
J1	Channel Improvement of Ja Ela (B=45 m, L=7 km) + Channel Improvement of Dandugam Oya (B=55-65 m, L=9.9 km) + Retention Area
J2	Channel Improvement of Ja Ela (B=50 m, L=7 km) + Channel Improvement of Dandugam Oya (B=60-70 m, L=9.9 km) + Retention Area
J3	Channel Improvement of Ja Ela (B=55 m, L=7 km) + Channel Improvement of Dandugam Oya (B=65-75 m, L=9.9 km) + Retention Area
J4	Channel Improvement of Ja Ela (B=45 m, L=7 km) + Channel Improvement of Dandugam Oya (B=55-65 m, L=9.9 km) + Kotugoda-Seeduwa Diversion (B=20 m, L=3.1 km) + Retention Area
J5	Channel Improvement of Ja Ela (B=60 m, L=7 km) + Channel Improvement of Dandugam Oya (B=70-80 m, L=9.9 km) + Retention Area
J6	Channel Improvement of Ja Ela (B=80 m, L=7 km) + Channel Improvement of Dandugam Oya (B=90-100 m, L=9.9 km) + Retention Area

Note: B and L mean width and length, respectively.

55. The expected storm water retention areas will exist at four locations as shown in Figure 4.2. They are divided into the upper and lower retention areas. The upper retention area is fixed at 376 ha, while the lower retention area is 1,357 ha at a maximum and changed by case for comparative study. The allowable water levels are set as follows:

Planning Scale (Return Period)	Ja Ela at Negombo Road	Dandugam Oya at Negombo Road	Lower Retention Area
50-year	1.65 m MSL	1.58 m MSL	3.50 m MSL

56. The minimum required retention areas, which coincide with areas at the allowable water levels, are studied for the respective cases and obtained as follows:

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
J1	920+376	2,663	264	1.10	10.9
J2	650+376	2,965	349	1.30	12.6
J3	560+376	3,507	394	1.24	12.1
J4	1,150+376	3,029	191	0.84	8.7
J5	500+376	3,679	440	1.34	12.9
J6	330+376	4,400	645	1.63	15.2

Study on Optional Planning Scales

57. In addition to the above study for the planning scale of a 50-year return period, the optional planning scales of 25-year and 10-year return periods are studied. The allowable water levels for each planning scale are set under the conditions of the present drainage system as follows:

Planning Scale (Return Period)	Ja Ela at Negombo Road	Dandugam Oya at Negombo Road	Lower Retention Area
25-year	1.47 m MSL	1.43 m MSL	3.24 m MSL
10-year	1.24 m MSL	1.22 m MSL	2.83 m MSL

58. The minimum required retention areas for the allowable water levels are obtained as follows:

a) Planning scale: 25-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
J1	1,170+376	2,222	132	0.66	6.5
J2	1,080+376	2,288	188	0.90	9.1
J3	950+376	2,381	266	1.22	11.9
J4	1,357+376	2,462	156	0.88	9.0
J5	930+376	2,471	282	1.25	12.2
J6	780+376	2,830	383	1.47	13.5

b) Planning scale: 10-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
J1	1,020+376	2,076	207	1.04	10.4
J2	950+376	2,147	250	1.22	12.0
J3	850+376	2,249	310	1.49	14.2
J4	1,357+376	2,345	137	0.88	9.1
J5	810+376	2,331	335	1.55	14.8
J6	680+376	2,699	420	1.69	15.2

Proposed Storm Water Drainage Plan

59. According to the results of the economic evaluation for the cases with a minimum required retention area, Case J6 has the highest economic viability among the cases studied for the planning scale of a 50-year return period. However, the assumed design channel widths (80 and 100 m) exceed the Colombo-Katunayake Expressway openings (60 and 80 m). Case J6 will cause re-design and re-construction of the opening and therefore it is not promising. Because of this, Case J5 becomes the best. Also, Case J5 has the best economic viability for the planning scales of 25-year and 10-year return periods. As a conclusion, Case J5 is selected for the Ja Ela basin. The proposed storm water drainage plan consists of the following measures and is shown in Figure 4.3.

Measures	Features
Channel Improvement of Ja Ela	Total length : 7.0 km, Width : 60 m
Channel Improvement of Dandugam Oya	Total length : 9.9 km Width : 80 m from Sta.3.5 to 7.5 km Width : 70 m from Sta.7.5 to13.5 km
Strom Water Retention Area	Lower area : 500 ha, Upper area : 376 ha

4.5 Storm Water Drainage Plan for Kalu Oya Basin

Basic Principle for Planning

60. The Kalu Oya basin has difficulty in natural drainage of storm water due to low-lying lands and the high water level of the Kelani Ganga during rainstorms. The Kalu Oya basin requires a solution for fundamental drainage problems and protection against future increase of storm water runoff due to the urbanization in the basin. The storm water drainage plan for the Kalu Oya basin should be formulated employing various measures such as channel improvement, diversion, pumping stations, securing of retention area, introduction of new storm water retention facilities.

Structural Measures

61. In order to select effective structural measures, the following measures shown in Figure 4.4 are first studied for the planning scale of a 50-year return period.

Case	Measures
K1	Channel Improvement of Kalu Oya (B=4 0m, L=5 km) + Retention Area
K2	Channel Improvement of Kalu Oya (B=45 m, L=5 km) + Retention Area
K3	Channel Improvement of Kalu Oya (B=50 m, L=5 km) + Retention Area
K4	Wattala Pumping Station (Q=10 m^3/sec) + Retention Area
K5	Wattala Pumping Station (Q=20 m^3/sec) + Retention Area
K6	Wattala Pumping Station (Q=30 m^3/sec) + Retention Area
K7	Diversion Channel to Muthurajawela Marsh (B=3 0m, L=2.4 km) + Retention Area
K8	Improvement of Old Negombo Canal (B=30 m, L=4.2 km) + Retention Area
K9	Improvement of Old Negombo Canal (B=35 m, L=4.2 km) + Retention Area
K10	Improvement of Old Negombo Canal (B=40 m, L=4.2 km) + Retention Area

Note: B, L and Q mean width, length and capacity, respectively.

62. The storm water retention areas in the Kalu Oya basin exist at several locations and are largely divided into upper and lower retention areas due to topographic features as shown in Figure 4.4. The upper retention area has an extent of 89 ha and the lower 434 ha. In the Study, the extent of the upper retention area is fixed and the lower retention area is changed for comparative study. The allowable water level in the retention area is set at 1.67 m above MSL for a 50-year probable flood under the present drainage system.

63. Considering the effectiveness of the alternative measures, the following alternative cases are prepared for the comparative study on the condition that the water level in the lower retention area does not exceed the allowable water level.

Case	Measures
K11	K1+K8+Retention Area
K12	K2+K9+Retention Area
K13	K3+K10+ Retention Area
K14	K1+K7+K8+Retention Area
K15	K1+K6+K8+Retention Area
K16	K1+K7+Retention Area
K17	K1+K9+Retention Area
K18	K1+K10+Retention Area
K19	K3+K7+K10+Retention Area
K20	K3+K6+K7+K10+Retention Area

64. The minimum required retention areas for the allowable water level of 1.67 m above MSL are obtained as presented in the table below.

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
K11	434+89	1,927	162	1.02	10.2
K12	434+89	2,182	192	1.08	10.7
K13	360+89	2,463	422	1.94	17.4
K14	290+89	2,806	655	2.61	21.9
K15	340+89	5,896	519	0.95	9.5
K16	340+89	2,390	493	2.33	20.0
K17	434+89	2,001	173	1.05	10.4
K18	434+89	2,136	182	1.04	10.4
K19	200+89	3,331	888	2.97	24.1
K20	160+89	7,422	1,113	1.65	15.5

Study on Optional Planning Scales

65. The optional planning scales of 25-year and 10-year return periods are also studied for the same alternative cases as for the 50-year return period. The allowable water level is set at 1.60 m above MSL for the 25-year return period and 1.51 m for the 10-year return period. The minimum required retention areas are obtained as follows.

a) Planning scale: 25-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
K11	434+89	1,772	148	1.08	10.7
K12	390+89	1,879	298	1.90	16.8
K13	330+89	1,975	489	2.84	23.0
K14	265+89	2,594	690	2.98	24.1
K15	250+89	5,762	797	1.53	14.6
K16	310+89	2,249	551	2.78	22.8
K17	434+89	1,802	161	1.17	11.3
K18	390+89	1,801	302	2.00	17.5
K19	175+89	2,807	987	3.90	29.3

b) Planning scale: 10-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
K11	434+89	1,751	149	1.25	11.8
K12	320+89	1,810	405	3.41	25.7
K13	250+89	1,899	618	4.66	32.1
K14	215+89	2,533	713	3.84	28.5
K15	150+89	5,671	969	2.66	21.9
K16	290+89	2,219	481	3.04	24.0
K17	325+89	1,704	389	3.50	26.2
K18	275+89	1,699	525	4.59	31.6

66. The diversion channel from the Kalu Oya to the Old Negombo Canal (Case K7) is evaluated as more effect than other cases. However, it has to cross the Colombo-Katunayake Expressway (CKE) presently under construction and the existing Negombo Road. The construction of the diversion channel may cause non-engineering problems as it is a completely new channel construction and a new

bridge has to be constructed crossing CKE. The diversion channel plan should be considered as a reference.

Proposed Storm Water Drainage Plan

67. Among the remaining cases after discarding the diversion channel plan, Case K13 has the highest economic viability and therefore it is proposed to select Case K13 for the Kalu Oya basin. The proposed storm water drainage plan for the Kalu Oya basin consists of the following measures and is shown in Figure 4.5.

Measures	Features
Channel Improvement of Kalu Oya	Total length : 5.0 km, Width : 50 m (Sta. 0.0 to 3.8 km) Width : 25 m (Sta. 3.8 to 5.0 km)
Improvement of Old Negombo Canal	Total length : 4.5 km, Width : 40 m
Strom Water Retention Area	Lower area : 360 ha, Upper area : 89 ha

4.6 Storm Water Drainage Plan for the Greater Colombo Basin

Basic Principle for Planning

68. The Greater Colombo basin is expected to be continuously urbanized toward the suburbs. This will result in an increase of the storm water runoff and worsen the storm water drainage condition unless further measures are provided. Due to limitation of available land for canal widening, it is essential to conserve the presently functioning storm water retention areas and also preserve other lowlands available for the purpose of storm water retention as much as possible. Based on that, structural measures such as channel improvement, diversion, pumping stations, tunnels, etc. should be taken to augment the capacities of the existing storm water drainage systems and increase the flood safety level.

Structural Measures

69. In order to select effective measures, the following measures shown in Figure 4.6 are first studied for the planning scale of 50-year return period. As a result, the cases including pumping station (G1 to G6) were discarded because they were not economically viable.

Case	Measures
G1	Mararadua Pumping Station (Q=5m^3/s) and Improvement of Galle Face Outfall Gates + Retention Area
G2	Mararadua Pumping Station (Q=10 m^3/s) and Improvement of Galle Face Outfall Gates + Retention Area
G3	North Lock Pumping Station (Q=10 m^3/s) + Retention Area
G4	North Lock Pumping Station (Q=15 m^3/s) + Retention Area
G5	Gotatuwa Pumping Station (Q=30 m^3/s) + Retention Area
G6	Gotatuwa Pumping Station (Q=40 m^3/s) + Retention Area
G7	Madiwela South Diversion Canal (B=40 m, L=8.8 km) + Retention Area
G8	Restoration of Existing Mutwal Tunnel (D=1.8 m, L=554 m) + Retention Area
G9	New Mutwal Tunnel (D=3 m, L=740 m) + Retention Area
G10	New Mutwal Tunnel (D=4 m, L=740 m) + Retention Area
G11	Improvement of Wellawatta (B=30 m, L=1,900 m) and Kirillapone Canals (B=25 m, L=1,200 m) + Retention Area

Note: B, L and Q mean width, length and capacity, respectively.

70. The retention areas are distributed at several locations such as Kolonnawa, Heen and Kotte Marshes as shown in Figure 4.6. The total area is 435 ha for the ground surface elevation of 2.0 m above MSL. On the other hand, the allowable water level is set at 1.75 m above MSL, which is referred to in various plans in the basin.

71. The following alternative cases are prepared for the comparative study.

Case	Measures
G12	G7+G8+Retention Area
G13	G7+G9+Retention Area
G14	G7+G10+Retention Area
G15	G8+G9+Retention Area
G16	G8+G10+Retention Area
G17	G7+G11+Retention Area
G18	G7+G8+G9+Retention Area
G19	G7+G8+G10+Retention Area
G20	G7+G8+G11+Retention Area
G21	G7+G9+G11+Retention Area
G22	G7+G10+G11+Retention Area
G23	G7+G8+G10+G11+Retention Area
G24	G4+G7+ G8+G10+G11+Retention Area

72. Among the alternative cases, the water levels of Cases 12 to 16 exceed the allowable water level of 1.75 m above MSL for a 50-year return period. The minimum required retention area at the allowable water level is obtained for the remaining cases as follows:

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
G17	435	5,393	678	1.40	13.5
G18	435	4,473	681	1.70	15.7
G19	380	4,389	886	2.23	19.5
G20	360	5,307	933	1.93	17.5
G21	320	5,940	1,114	2.06	18.4
G22	290	6,009	1,251	2.28	20.0
G23	280	6,133	1,303	2.33	20.3
G24	170	8,804	1,850	2.32	20.3

Study on Optional Planning Scales

73. The optional planning scales of 25-year and 10-year return periods are also studied for the same cases for 50-year return period. The allowable water level of 1.75 m above MSL is applied for both planning scales. For the 10-year return period, the water level in the retention area under the present drainage system comes to 1.53 m above MSL, which is much lower than the allowable water level of 1.75 m above MSL. No combination of component structural measures is considered.

74. The minimum required retention areas at the allowable water level are obtained as follows:

a) Planning scale: 25-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
G7	190	3,327	1,144	3.74	27.8
G10	340	855	452	5.72	38.3
G12	170	3,451	1,247	3.94	29.8
G13	150	4,112	1,373	3.65	28.2
G14	135	4,181	1,461	3.83	29.1
G15	320	908	478	4.83	37.4
G16	310	978	549	6.09	39.8
G17	125	4,305	1,515	3.86	29.3

b) Planning scale: 10-year return period

Case	Minimum Required Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
G8	120	302	103	3.81	28.9
G9	90	785	295	4.22	30.8
G10	65	855	393	5.12	35.1

Proposed Storm Water Drainage Plan

75. For the planning scale of a 50-year return period, Cases G19, G22, G23 and G24 indicate high B/C and EIRR. Case G19 indicates the least cost among the cases and also comprises the components of the Cases G10 and G8 showing the highest economic viability for the 25-year and 10-year return period, respectively. Case 19 is

therefore selected as the storm water drainage plan for the Greater Colombo basin. The proposed storm water drainage plan for the Greater Colombo basin consists of the following measures and is shown in Figure 4.7.

Measures	Features
Madiwela South Diversion Channel	Total length : 8.8 km, Width : 32 m
Restoration of Existing Mutwal Tunnel	Total length : 554 m, Diameter : 1.8 m
New Mutwal Tunnel	Total length : 740 m, Diameter : 4.0 m
Storm Water Retention Area	380 ha

4.7 Storm Water Drainage Plan for Bolgoda Basin

Basic Principle for Planning

76. The Bolgoda basin is characterized by the drainage system in the downstream lowland consisting of the two major lakes and waterways interconnecting with each other. According to the future land use projection, extensive urbanization in the basin is not expected except in the Weras Ganga basin in the northern part of the Bolgoda basin. It is essential to conserve the existing water surface areas and surrounding lowlands from the viewpoints of storm water retention as well as environmental protection in the entire Bolgoda basin.

77. On the other hand, the Weras Ganga basin requires channel improvement of the main stream and major tributaries to cope with runoff increase due to urbanization and mitigation of the flood damage in the basin. Therefore, the storm water drainage plan for the Bolgoda basin is formulated focusing on the storm water drainage plan for the Weras Ganga basin.

Structural Measures

78. The conceivable measures for the Bolgoda basin are shown in Figure 4.8. Further, the conceivable structural measures for the Weras Ganga and tributaries are shown in Figure 4.9 and grouped into the component schemes broadly demarcated by sub-basin as follows:

Component Scheme	Measures
(1) Weras Ganga	• Weras Ganga Dredging (L=5.5 km) • Flood Protection Wall on Right Bank (L=2.3 km) • Weras Ganga Swamp Retention Area: 65 ha • Maha Ela Marsh and Lowland Retention Area: 132 ha
(2) Nugegoda-Rattanapitiya Scheme	• Channel Improvement of Nugegoda-Ela (L=1.58 km) • Channel Improvement of Delkanda Ela (L=1.76 km) • Channel Improvement of Rattanapitiya Ela (L=2.13 km) • Retention Areas: total extent 36 ha
(3) Bolgoda Canal Scheme	• Channel Improvement of Bolgoda Canal (L=2.4 km) • Bellanwila-Attidiya Marsh Retention Area: 108 ha
(4) Boralesgamuwa North Scheme	• Channel Improvement of Depawa Ela (3.09 km)
(5) Boralesgamuwa South Scheme	• Channel Improvement of Werahara Tributary (L=0.98 km)
(6) Maha Ela Scheme	• Channel Improvement of Maha Ela (L=2.7 km) • Channel Improvement of Maha Ela Tributary (L=1.76 km)
(7) Ratmalana-Moratuwa Scheme	• Urban Drainage Improvement (L=11.12 km) • Kandawala Retention Pond: 3 ha • Telewala Retention Pond: 10 ha • Channel Improvement of Katubedda Tributary (L=1.25 km) • Retention Area: 23 ha

Note: L means length.

79. Among the measures, the alternative dredging widths of 20, 40, and 60 m for the Weras Ganga are examined by hydraulic analysis under the storm water drainage plan comprising all the component schemes and retention areas described above. The results are summarized by water level at three major base points as follows:

Dredging Width	Water Level (above MSL)		
	Elawella Road	Borupana Bridge	Confluence of Maha Ela
20 m	1.42	1.01	0.95
40 m	1.41	0.99	0.93
60 m	1.41	0.96	0.88

80. The storm water drainage plans with different dredging widths are economically evaluated by befit-cost ratio (B/C) and economic internal rate of return (EIRR) for each alternative. The results are summarized below. The dredging width of 40 m is selected as the optimum one.

Dredging Width	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
20 m	5,128	624	1.50	13.9
40 m	5,317	706	1.60	14.7
60 m	5,657	715	1.52	14.1

Required Extent of Retention Area in Weras Ganga Basin

81. The storm water retention areas under future land use projection are demarcated as shown in Figure 4.10. Influence by loss of retention area is examined for the 50-year probable flood with a relationship between extent of retention area and average of

water level in the Weras Ganga. The average water level in the case of 'without' project is regarded as an allowable water level. The required retention areas for the allowable water level are shown in Figure 4.11 and the extent of each retention area is obtained as follows:

Retention Area	Retention Area under Future Land Projection (ha)	Required Extent of Retention Area (ha)
Upper Nugegoda Ela	7	7
Lower Nugegoda Ela	20	20
Delkanda Ela	9	9
Bellanwila-Attidiya Marsh	108	88
Weras Ganga Swamp and Surrounding Marsh	65	65
Maha Ela Marsh and Lowland	132	106
Katubedda Tributary	23	0
Thumbowila Tributary	8	0
Total	372	295

82. The economic evaluation of the proposed storm water drainage plan for the Weras Ganga basin is made for the required retention area of 295 ha. In the evaluation, the balance of 77 ha is assumed to be used for development purpose. The results are summarized as follows:

Retention Area	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B-C (million Rs.)	B/C	EIRR (%)
295 ha	5,102	1,022	3,768	2.22	19.2

Study on Optional Planning Scales

83. The optional planning scales of 25-year and 10-year are also studied for the same alternative measures as for a 50-year return period. The water levels at three base points in the Weras Ganga are given below, which are

Dredging Width	Water Level (above MSL)		
	Elawella Road	Borupana Bridge	Confluence of Maha Ela
25-year	1.33	0.92	0.85
10-year	1.20	0.82	0.77

84. The required extent of retention area for each planning scale and economic evaluation result are summarized as follows:

Return Period	Retention Area (ha)	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
25-year	295	5,100	1,012	2.29	19.6
10-year	295	5,099	955	2.17	18.8

Effect of Reduction of Lowlands in the Bolgoda Basin

85. Further, the effect of reduction of the low-lying area surrounding the North and South Bolgoda Lakes is studied for the 50-year probable flood. The results are summarized below.

Delimitation Level (m MSL)	Low-lying Land Area (ha)	Water Level (above MSL)		
		Weras Ganga at Base Point	North Bolgoda Lake	South Bolgoda Lake
1.5	4,739	1.43	0.69	0.78
1.0	3,710	1.51	0.70	0.79
0.5	2,227	1.73	0.74	0.83
0.0	950	1.89	0.78	0.92

86. The total area of North and South Bolgoda Lakes is 1,100 ha at 0.10 m above MSL. The above results indicate that the water level rise in both lakes is about 5 cm even if half of the low-lying areas disappeared. However, it should be noted that the above results are obtained under the condition that the Bolgoda basin is subject to only light development up to the target year 2010. If the entire basin is well developed, the water level of both lakes will increase greatly.

Proposed Storm Water Drainage Plan

87. According to the results above, the proposed storm water drainage plan for the Bolgoda basin consists of the following seven schemes shown in Figures 4.12 and 4.13.

1) Weras Ganga Sub-basin

Component Scheme	Measures
(1) Weras Ganga	• Weras Ganga Dredging (L=5.5 km, B=19-40 m) • Flood Protection Dike on Right Bank (L=2.3 km) • Weras Ganga Swamp Retention Area (65 ha) • Maha Ela Marsh and Lowland Retention Area (106 ha)
(2) Nugegoda-Rattanapitiya Scheme	• Channel Improvement of Nugegoda-Ela (L=1.58 km, B=5-13 m) • Channel Improvement of Delkanda Ela (L=1.76 km, B=3-13.5m) • Channel Improvement of Rattanapitiya Ela (L=2.13 km, B=19 m) • Retention Areas(36 ha in total)
(3) Bolgoda Canal Scheme	• Channel Improvement of Bolgoda Canal (L=2.4 km, B=17-19 m) • Bellanwila-Attidiya Marsh Retention Area (88 ha)
(4) Boralesgamuwa North Scheme	• Channel Improvement of Depawa Ela (L=3.09 km, B=6 m)
(5) Boralesgamuwa South Scheme	• Channel Improvement of Werahara Tributary (L=0.98 km, B=15 m)
(6) Maha Ela Scheme	• Channel Improvement of Maha Ela (L=2.7 km, B=32 m) • Channel Improvement of Maha Ela Tributary (L=1.76 km, B=15 m)
(7) Ratmalana-Moratuwa Scheme	• Urban Drainage Improvement (L=11.12 km, B=0.8-6 m) • Kandawala Retention Pond (3 ha) • Telewala Retention Pond (10 ha) • Channel Improvement of Katubedda Tributary (L=1.25 km, B=8 m)

Note: L and B mean length and width, respectively.

2) Entire Bolgoda Basin
   - Conservation of lowlands in the entire Bolgoda basin as a storm water retention area (4,739 ha)

4.8 Non-structural Measures for Storm Water Drainage

88. An effective storm water drainage plan should be formulated as a combination of structural and non-structural plans. In the study area, the following non-structural measures will support the structural measures taking into account the basin conditions.

1) Storm water retention area management
2) Development control in urban development areas
3) Land use regulation in lowland areas
4) Dissemination of flood information to the public
5) Flood-proofing of buildings in flood-prone areas
6) Flood fighting

89. *Storm Water Retention Area Management*: This is a sort of floodplain management. As mentioned in the proposed storm water drainage plan, the role of the storm water retention area is very important from the technical and economic viewpoints. If the storm water retention area is not provided, it is quite difficult to confine the storm water in the river channel and also attempting to do so would require a huge outlay. Therefore, it is proposed to keep the storm water retention areas through the following measures.

1) Legal designation of storm water retention areas
2) Regulation of land use in storm water retention areas
3) Strict legal action for illegal activities

90. *Development Control in Urban Development Areas*: Urbanization in the study area will cause an increase in flood runoff, while there is a limit to the possible increase in the discharge capacity of rivers and drainage canals to cope with the flood runoff increase. In order to reduce the flood runoff in the urbanized area, all developers, including the government agencies in charge of urban development, should require construction of storm water retention facilities in the implementation of the development projects. To ensure the construction of the storm water retention facilities, legislation for mandatory construction is proposed.

91. *Land Use Regulation in Lowlands*: As often seen in the study area, the houses affected by storm water inundation are mostly located in and around the lowlands, which are originally flood-prone areas. To stop recurrence of the same situation, it is proposed to regulate the land use in the lowland areas so as to stop dwelling in the flood-prone lowland.

92. *Dissemination of Flood Information*: To properly conserve the retention areas, various information such as relevant regulations, prohibited activities, boundaries of the retention areas, etc. should be disseminated to the public to promote their understanding and awareness for the flood control. Further, it also will be effective for mitigation of the flood damage to disseminate the information on flooding conditions of the residential areas and lowlands to the public. Based on the information disseminated, the people may avoid dwelling in the areas with flood risk such as lowlands and also learn how to cope with flood.

93. *Flood-proofing of Buildings in Flood-prone Areas*: In principle, it is better to relocate the houses in the flood-prone areas such as marsh and natural flood retention areas to mitigate the flood damages. However, if it is decided to continue dwelling in the flood-prone areas,, flood-proofing of the buildings (houses) should be introduced, such as raising of foundation ground, introduction of piloti type buildings, wall-fencing around houses and waterproof buildings.

94. *Flood Fighting*: If a flood exceeding the design flood scale occurred, flood damage is inevitable. In order to mitigate the flood damages as much as possible, precautionary measures such as flood fighting, dissemination of information on flooding condition to the public, etc. should be taken. The flood fighting system has been established in the study area. The existing flood fighting system should be fully utilized.

4.9 Outfall Treatment

95. The outfalls facing a problem of clogging are those of Dehiwela canal, Lunawa Lake and Tarpitiya canal. Among them, the outfall of Tarpitiya canal does not have a major role for storm water drainage in the Bolgoda basin. The Bolgoda Ganga, Pandora Ganga, Aluth Ela and Kapu Ela have a major role for storm water drainage with Bolgoda Lake North and South.

96. At the Dehiwela outfall, construction of two groins was completed in July 2002. The continuous opening of the Dehiwela outfall will contribute to reduce the flood water level in the Greater Colombo basin. However, the groins have just been constructed and the effect and impact of the groins are uncertain at present. It is quit important to carefully monitor the coast behavior between Dehiwela outfall and Wellawatta outfall including the surrounding areas.

97. The Lunawa Lake basin is independent and the “Lunawa Lake Environment Improvement Project and Community Development Project” is under implementation. For the time being, manual excavation is recommended, but further study to keep the outfall open continuously should be made referring to the monitoring results for the groins of the Dehiwela outfall.

4.10 Institutional Development Plan

98. Institutional and legislative issues on the storm water drainage works are 1) unclear responsibilities among government agencies for storm water drainage works, 2) lack of an authorized land use plan, 3) malfunction of the regulation system for low land development and 4) shortage of resources for the storm water drainage works.

99. *Demarcation of Responsibility:* The demarcation of responsibility for the storm water drainage works among the related organizations, that is, SLLRDC, local authorities (LA), Road Development Authority (RDA) and the Irrigation Department (IRD), is proposed considering the present situation as below.

Objective Area	Planning	Construction	Maintenance
Within Provincial Basin			
Declared Area by SLLRDC	SLLRDC	SLLRDC	SLLRDC
Area of Local Authority	LA	LA	LA
Road Side Drain	RDA	RDA	LA
Inter-provincial Basin			
Irrigation Canals and Rivers Situated in the Inter-provincial Basin	IRD	IRD	IRD

100. *Lowland Management by SLLRDC*: Despite the fact that the importance of lowland conservation for flood control is generally recognized, currently, the areas to be conserved are not clearly identified and both legal and illegal fillings are proceeding for various developments without a proper land use plan. The present land use regulation system is complicated and not functioning satisfactorily. It is proposed to establish lowland management by SLLRDC for storm water drainage by the following approach.

1) Empowerment of the SLLRDC as the sole agency for the lowland management for storm water drainage works,
2) Formulation of an authorized land use plan for land use regulation,
3) Combined activities with local authorities to utilize the powers of local authorities to curb illegal activities, and
4) Achievement of social understanding on the lowland management.

4.11 Operation and Maintenance Plan

Policy for Operation and Maintenance

101. The O&M plan is prepared based on the following policy.

1) The responsible organizations for O&M of the storm water drainage facilities are SLLDC and local authorities.
2) SLLRDC is responsible for O&M of drainage facilities in the declared areas.

3) Local authorities are responsible for O&M of drainage facilities in their respective land areas.
4) SLLRDC should assist the local authorities in undertaking the O&M works for the drainage facilities for a few years after transfer of those facilities to local authorities.
5) As a long term objective, local authorities should promote expansion of resources so as to conduct the storm water drainage works by themselves.

Organization set-up and staff arrangement

102. *SLLRDC*: A new section is proposed in the existing CD&M division to undertake O&M works for the storm water drainage system in built up areas and for provision of technical guidance and staff training on O&M of storm water drainage systems to the local authorities except CMC. As a long term target, it is proposed to promote the expansion of the SLLRDC's organization to undertake overall works in the flood control/storm water drainage sector including planning, implementation, O&M and regulation/instruction activities on land filling, and further, to provide technical guidance, training and flood information for local authorities.

103. *Local Authorities*: Colombo MC has an established O&M system and work forces for O&M works are available, however it is proposed to arrange the staff for O&M of the major urban drainage channels to improve the quality of the O&M works. On the other hand, the local authorities other than CMC have not yet established organizations for storm water drainage works because of less need. However, it is proposed to establish organizations to exclusively undertake storm water drainage works with key staff to cope with the future development of storm water drainage systems.

104. Especially, Dehiwela - Mount Lavinia MC and Moratuwa MC should complete the above organizational set-up with staff arrangement in a few years since the storm water drainage facilities being constructed by SLLRDC in their areas are scheduled to be transferred to both local authorities.

Equipment Plan

105. The O&M equipment presently owned by SLLRDC will be not enough to handle the O&M works for the entire Greater Colombo canal system and the responsible area extended in the future. Therefore, in the long term, it is proposed to procure some additional heavy equipment such as a dredger for maintenance of major canals in the above areas. On the other hand, the O&M equipment presently owned by local authorities except CMC is quite insufficient for undertaking the O&M works on a regular basis. It is proposed to procure the O&M equipment such as tractors, dump trucks, back hoes, water pumps, etc. to fulfill the regular O&M activities.

Financial Arrangement

106. *SLLRDC*: The financial source for the O&M works of SLLRDC is the Government budget. SLLRDC should make due arrangement to acquire enough budget for required O&M works based on the work plan, staff employment/training plan and equipment plan. The annual budget required for the O&M works to be done by SLLRDC is roughly estimated at Rs. 7 million.

107. *Local Authorities*: CMC will easily be able to arrange the budget for the O&M works because of its considerably large budget scale compared to other local authorities. On the other hand, the annual budgets of other local authorities allocated for O&M works are too small to carry out substantial regular works. It is proposed that Western Provincial Council review this financial arrangement so that the local authorities can achieve the minimum required O&M works.

4.12 Human Resources Development Plan

108. Human resources development for management of the entire storm water drainage works as well as the O&M works will be a key issue for implementation agencies, that is, SLLRDC and the local authorities. As a human resources development plan, an O&M training program for SLLRDC and local authorities is proposed as a short-term objective. Furthermore, as a long term objective, an overall training program for human resource development in the storm water drainage sector is proposed for the continuous capability building of staff at all levels in SLLRDC and local authorities.

O&M Training Program for SLLRDC and Local Authorities

109. As a short term objective, an O&M training program is proposed for the O&M related staff of SLLRDC and local authorities. For SLLRDC, execution of a strengthening program utilizing the existing materials (O&M manual, etc.) and system is proposed to enhance the capability for the O&M activities. For the local authorities, on-the-job training and lectures under the leadership of SLLRDC are proposed. This is the most effective way to execute the on-the-job training in the process of handing over the drainage system constructed by SLLRDC to the local authorities.

Overall Training Program for Human Resources Development

110. *Target Training Participants*: For SLLRDC, it is proposed that the training should target the staffs of not only the engineering and technical areas but also managerial/administrative and social development areas analyzing the current work performance of SLLRDC. For the local authorities, it is proposed that the training should aim at developing human resources such as the engineers specialized in the

storm water drainage works taking into account the present understaffing in all local authorities except CMC.

111. *Training Package*: The training package consists of four categories of managerial and administrative, technological and technical, social development and O&M in order to strengthen the capabilities of staffs in charge of the storm water drainage works. The proposed training providers are SLIDA for managerial staff training, SLILG for technical, management and social development fields, NIBM for the business management field, CHPB for engineers and technical staff training and PTU/WP for managerial, administrative and technical fields.

5. CONSTRUCTION PLAN AND COST ESTIMATE

5.1 Construction Plan

112. The major construction works will be executed by contractors selected through international competitive bidding (ICB) complying with the regulations of the Government of Sri Lanka and the guideline of the international financing organizations. In addition, it will be necessary to study the possibility of using local contractors in order to reduce the construction cost and to improve the construction management capacity of the local contractors in Sri Lanka, by dividing the works into small packages.

113. The construction period of each component of the proposed storm water drainage plan is estimated at 3 to 4 years taking into account work volumes of the proposed projects and also construction periods of past similar projects. The overall construction schedule is shown in Figure 9.1.

5.2 Cost Estimate

114. The financial project cost comprises the following cost items.

1) Construction cost
2) Land acquisition and compensation cost
3) Engineering service cost
4) Administration cost
5) Price escalation
6) Physical contingency
7) Tax

All costs are estimated at August 2002 price level. The exchange rate is set at US$1.0 = Rs 96.26 =¥118.94.

115. Each cost item is estimated by the following method.

Cost Item	Method
1) Construction cost	Unit price
2) Land acquisition and compensation cost	Unit price
3) Engineering service cost	15% of construction cost
4) Administration cost	15% of ［1) + 2) + 3)］
5) Price escalation	0.8% for foreign currency 2.8% for local currency
6) Physical contingency	10% of ［1) + 2)］ 5% of ［equipment cost + 3) + 4)］
7) Tax	30% of construction cost 40% of equipment cost 20% of engineering service cost

116. The estimated project costs of the proposed storm water drainage plans are presented in Table 5.1. The total costs are as follows:

Basin	Project Cost (million Rs.)
Storm Water Drainage Plan for Ja Ela Basin	3,679
Storm Water Drainage Plan for Kalu Oya Basin	2,463
Storm Water Drainage Plan for Greater Colombo Basin	4,389
Storm Water Drainage Plan for Bolgoda Basin	5,102

117. Annual O&M costs of the channel and other civil structures are assumed at 1% of the construction cost. While, the annual O&M costs for pumping stations and gates are estimated at 2.5% of the construction cost.

6. ENVIRONMENTAL CONSIDERATIONS

6.1 Initial Environmental Examination Study

Environmental Legislation in Sri Lanka

118. The National Environmental Act No.47 of 1980 (NEA) is the basic national charter for protection and management of the environment. Under this Act, the Central Environmental Agency (CEA) was formed as the agency charged with the responsibility of implementing the provisions of the NEA. The subsequent amendment to this Act empowers the CEA to implement a scheme for the control of pollution and to assess impacts on the environment from development activities.

119. Only large-scale development projects likely to have significant impacts on the environment are listed as prescribed projects for the Environmental Impact Assessment (EIA) process and given in the Gazettes. The project-approving agency (PAA) will be responsible for administering the EIA process. If PAA is the project proponent, CEA will act as PAA. CEA is responsible for implementing the required

provisions of NEA, and will advise PAA to amend the relevant acts, orders and regulations.

Environmental Screening and Scoping

120. *Ja Ela basin:* A rise of water level in the Muthurajawela Marsh is expected to be caused by the proposed Ja Ela and Dandugam Oya channel improvement during rainstorms. The breeding sites for some kinds of birds in the marsh might be affected by the water level rise. The environmental impact to feeding grounds for fauna will be minimal since the fauna such as birds can temporarily evacuate to a safe place during rainstorms. Any negative environmental impact to flora is not expected to occur due to the short time of inundation. No serious problem regarding land acquisition and resettlement for the proposed storm water drainage plan is expected.

121. *Kalu Oya basin:* The storm water will be mostly discharged into the conservation zone of the Muthurajawela Marsh by the proposed Kalu Oya channel and Old Negombo Canal improvement. Since the higher water level will last only for a short time, the environmental impact to the Muthurajawela Marsh will be the same as that mentioned for the Ja Ela basin above. Also, no serious problem regarding land acquisition and resettlement for the proposed storm water drainage plan is expected.

122. The Kalu Oya basin will be well urbanized in the future according to the future land use pattern. There is a possibility that a large volume of pollutants from the urbanized area will flow into the Muthurajawela Marsh through the improved Old Negombo Canal and the polluted water might cause an environmental impact to the habitats for flora and fauna unless the wastewater is properly treated within the urban area.

123. *Greater Colombo basin:* Active conservation of the existing marshes, such as Kolonnawa, Kotte and Heen Marshes, as a retention area with proper management will bring about positive effects for both ecological and urban environments in the basin. The proposed restoration of the existing Mutwal Tunnel and construction of the new Mutwal Tunnel will not cause any serious environmental impact by themselves. However, the leachate from the solid waste dumping site along the Main Drain leading to the tunnels may contaminate the seawater of the coastal area around the tunnel outlets unless the solid waste dumping site is properly managed.

124. By construction of the proposed Madiwela south diversion, the storm water diverted from the Parliament Lake basin to the Weras Ganga may cause a water level rise of the Weras Ganga and the Bolgoda Lake North. However, no harmful impact will occur since the water level rise is estimated at 10 cm for the Weras Ganga and 3 cm for the Bolgoda Lake North. No serious problem regarding land acquisition and resettlement for the proposed storm water drainage plan is expected.

125. *Bolgoda basin:* In the Bolgoda basin, channel improvement in the Weras Ganga sub-basin was proposed. The proposed channel improvement will reduce the flood water level in the sub-basin, while the water level of the Bolgoda Lake North will raise a few cm. Since the water level rise is small, no harmful impact will occur. There exists the Bellanwila-Attidiya Marsh in the Weras Ganga sub-basin. The water level in the Marsh area will not rise due to the proposed channel improvement. The proposed storm water drainage plan will not cause an environmental impact to habitats for flora and fauna in the Marsh. No serious problem regarding land acquisition and resettlement is expected due to the proposed storm water drainage plan.

6.2 Environmental Issues Relevant to the Canal Systems

Wastewater

126. In the proposed storm water drainage plans for the objective four basins, storm water retention areas are selected in the lowlands such as marshes and abandoned paddy lands. The retention areas will receive the wastewater through the canals in the densely populated areas. Inflow of the wastewater would cause a negative impact to the ecology of the lowlands designated as a storm water retention area. In addition, stagnation of the pollutants in the canals accelerates the water quality deterioration process. It causes extraordinary growth of water hyacinth and results in blocking of storm water passage in many places of the canals. Treatment of the wastewater should be considered in relation to the storm water drainage project.

Solid Waste

127. Dumping of solid waste into the canals is common practice in many places of the study area due to lack of solid waste collection service and lack of public concern. This practice causes blocking of the storm water drainage canals as well as water quality deterioration. Local authorities are responsible for the collection and disposal of solid waste in the study area. The majority of the dumping sites is in low-lying areas such as marshy lands and abandoned paddy lands, which have a function of storm water retention. The illegal dumping of solid waste should be strictly prevented by legal actions and authorized dumping sites should be prepared as an alternative.

7. SOCIAL CONSIDERATIONS

Poverty Reduction Program

128. Subsequent to the formulation of a framework for poverty reduction, the Government has drafted a poverty reduction strategy. The Department of External Resources is a coordination agency among the relevant governmental agencies, NGOs, CBOs and

ad-hoc committees. The strategy will provide a concrete target, action, and implementation schedule from 2002 to 2005 on poverty reduction for whole country.

129. The Government is currently carrying out infrastructure programs for the under-served settlements such as the Sustainable Township Program for re-housing of 66,000 low-income households in 5 years from 1999 to 2004 and the Public Utilities Program for upgrading and provision of infrastructure such as water supply, sanitation and construction of community centers and pre-schools.

130. The community contract system was introduced as a new approach to poverty reduction under the Million Houses Program in 1980s. Communities themselves as contractors under supervision of the relevant agency construct the community infrastructures and amenities such as footpaths, drains, toilets and community centers. Only a community registered as a Community Development Council (CDC) can have a right for the contract. This system was applied in the GCFC&EIP for upgrading and newly constructing community infrastructure such as community drains in both resettlement sites and on-site upgrading. In some locations, NGOs and JOCV staff assisted community formulation and registration procedures.

Lessons from Past Projects

131. In the urbanized portion of the study area, there exist many settlements in the flood-prone lowland areas and along the drainage canals, where the proposed storm water drainage projects would be located. Under this circumstance, land acquisition and resettlement are inevitably anticipated for implementation of the proposed projects. For smooth resettlement, people affected by the proposed projects should be fairly compensated so as not to lower their life conditions, especially for the under-served settlements and low income households, but also to upgrade their living environment through project implementation.

132. Previous works and experiences in the GCFC&EIP are useful for projecting social impacts on the people affected by the proposed storm water drainage projects. The key points for successful implementation of the projects will be as follows:

1) Participatory planning approach,
2) Improvement of living environment of residents,
3) Assistance for community-based organization for successful resettlement,
4) Introduction of community-based activities such as community contracts and
5) Coordination among stakeholders.

8. PROJECT EVALUATION

Economic Evaluation

133. For the quantitative economic evaluation of the proposed storm water drainage plans, flood damage reduction benefit and land enhancement benefit are considered. The flood damage reduction benefit is produced by a decrease of the flood water level and a corresponding decrease in the inundation area in the areas damaged by the floods. The land enhancement benefit is produced by an increase of land value resulting from creation of the flood free lands. On the other hand, the economic cost is estimated by deducting transfer payments and the local currency portion from the financial cost.

134. The economic viability of the proposed storm water drainage project for each basin is evaluated by means of benefit - cost ratio (B/C) and Economic Internal Rate of Return (EIRR). Life of the proposed project is assumed to be 40 years and discount rate applied is 10%. The results of the economic evaluation for the proposed storm water drainage projects are summarized below. All the proposed storm water drainage projects are economically viable.

Project	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
Ja Ela Basin	3,679	388	1.34	12.9
Kalu Oya Basin	2,463	422	1.94	19.5
Greater Colombo Basin	4,389	886	2.23	19.8
Bolgoda Basin	5,102	1,022	2.22	19.2

135. The target year of socio-economic frame in the present Study is set at 2010. If achievement of the planned socio-economic framework requires a longer term, the economic evaluation will give different results. Changing the target year to 2020, the economic evaluation results are as follows:

Project	B/C	EIRR (%)
Ja Ela Basin	1.02	10.2
Kalu Oya Basin	1.13	11.0
Greater Colombo Basin	1.61	14.4
Bolgoda Basin	1.67	14.7

The proposed storm water drainage projects for the Greater Colombo basin and Bolgoda basin have sufficient economic viability for delay of the achievement of the planned socio-economic framework.

136. In addition to the above quantitative benefits, many intangible benefits are expected from the implementation of the proposed storm water drainage projects. They are:

1) Promotion of economic development
2) Improvement of people's living conditions

3) Reduction of inconvenience in people's life
4) Improvement of the hygienic environment
5) Elimination of the menace of flooding
6) Improvement of the water environment
7) Contribution to poverty reduction

Technical Evaluation

137. The proposed storm water drainage projects include construction of dike, revetment, channel, bridge, tunnel and sluiceway. No constraint for implementation of the projects is found from the technical viewpoint such as design, construction and O&M since no special technology is needed for most of the construction works, which can be done by Sri Lanka Side in technical level. For the construction of the new Mutwal Tunnel and the crossing at High Level Road for Madiwela South Diversion Canal, participation of the international contractors will be advisable..

Environmental Evaluation

138. The proposed storm water drainage projects for the objective four basins are not expected to cause any critical environmental impacts. High water is expected for a short duration in the marsh areas and therefore, breeding sites of birds might be affected, but environmental impacts to habitats for fauna and flora will occur only rarely. Also, the project sites are not located in any environmentally sensitive areas.

139. Water quality in the drainage canals is low. It should be improved and maintained by proper treatment from the environmental viewpoint. Also, dumping of garbage into the retention areas and canals will decrease retention capacity and flow capacity of the drainage system. It should be eliminated.

Social Evaluation

140. As for the social aspect in implementation of the proposed storm water drainage projects, land acquisition and resettlement are important issues to be solved. The proposed projects are inevitably accompanied with land acquisition and resettlement. However, no critical location in the proposed project areas has been identified so far in ethnic, religious, cultural and historical aspects in connection with land acquisition and resettlement activities.

141. About 19,000 households, which may be affected by the proposed projects, are under the poverty line with a monthly income level of less than Rs. 3,000. The implementation of the proposed projects could contribute to improvement of their living conditions by incorporating it into the project scope and consequently contribute to poverty reduction. The proposed projects therefore will have a positive social impact.

Overall Evaluation

142. It is concluded that the storm water drainage plans proposed for the four objective basins of Ja Ela, Kalu Oya, Greater Colombo and Bolgoda basins are economically, technically, environmentally and socially viable for the planning scale of a 50-year return period. Also, it should be noted that implementation of the proposed storm water drainage projects will contribute to poverty reduction through reduction of flood damage, development of the study area, improvement of living conditions of the low-income group, etc.

9. PROJECT IMPLEMENTATION PLAN

143. The basic principles for project implementation are as follows;

1) All basins are given equal priority.
2) Multiple construction projects will not be implemented concurrently within any one basin in order to reduce the financial burden as much as possible.
3) Non structural measures, an institutional development plan, O&M plan and human resources development plan are to be implemented from the initial stage.
4) Storm water retention facilities are to be constructed as part of urban development
5) Annual disbursement costs are to be as even as possible.

144. Based on the basic principles mentioned above, the overall implementation schedule is prepared as shown in Figure 9.1. The maximum annual disbursement of the project costs comes to around Rs. 2.1 billion in total, which is less than the current budget for construction of SLLRDC, which is Rs. 2.2 billion. In terms of annual disbursement, it may be possible for SLLRDC to implement the project as proposed in the master plan with the continuous financial coverage by the central government. On the other hand, investment cost of Rs. 15.6 billion in total should be procured from an international funding agencies taking into account the present severe financial condition of the Sri Lanka Government.

10. SELECTION OF THE PRIORITY PROJECT

145. For the subsequent feasibility study, a priority project has to be selected. The criteria for selection of the priority project are set as follows.

1) The project is to be economically, technically and environmentally viable.
2) The project does not incur serious social problems in land acquisition and resettlement.
3) The project is expected to contribute to poverty reduction.

4) The area is expected to be highly developed in the future.
5) The project having higher economic viability should have priority after meeting the above conditions.

146. All the proposed storm water drainage projects (structural measures) are examined based on the above criteria as given in Table 10.1. The overall evaluation result is given below.

Project	Overall Evaluation
Ja Ela Basin Storm Water Drainage Project	C
Kalu Oya Basin Storm Water Drainage Project	B
Greater Colombo Basin Storm Water Drainage Project	B
Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Project	A

Note: Rank A is the best, and followed by B and C in order.

147. Based on the above result and priorities set by the Sri Lanka government, the Bolgoda Basin (Weras Ganga Sub-basin) Storm Water Drainage Project is selected as a priority project for the feasibility study. The number of resettlement households (158) is much smaller than other basins (more than 500) and also the land acquisition area is the smallest among the four basins. The rate of poor households, of which monthly income is less than Rs. 3,000, is as high as 35%, so that the proposed plan could improve the people's living conditions and consequently contribute to poverty reduction. It is judged that selection of the Weras Ganga sub-basin will be reasonable.

148. The priority project is named the Weras Ganga Basin Storm Water Drainage Project and component schemes of the priority project will be selected from seven schemes proposed in the master plan through further study in the feasibility study.

11. CONCLUTIONS AND RECOMMENDATIONS ON MASTER PLAN

Conclusions

149. It is concluded that the storm water drainage plans proposed for the four basins, Ja Ela, Kalu Oya, Greater Colombo and Bolgoda are economically and technically viable for the planning scale of a 50-year return period. Also, no serious environmental or social issues, which could hamper the implementation of the proposed storm water drainage plans, are expected.

150. The proposed storm water drainage projects are expected to yield various benefits not only flood damage reduction but also other tangible and intangible benefits mentioned before. According to the community inventory survey carried out in the Study, the ratios of poor households to total households of GN divisions having flood damages are estimated at 37% for the Ja Ela (6,000 households) and Kalu Oya basins (7,000

households), 24% for the Greater Colombo basin (27,000 households) and 35% for the Bolgoda basin (22,000 households). Many of them will be beneficiaries of the proposed storm water drainage plans. The proposed storm water drainage projects could improve their living conditions and consequently contribute to the reduction of poverty.

151. Regarding the priority project subject to a feasibility study, the storm water drainage project for the Weras Ganga sub-basin in the Bolgoda basin was selected based on consideration from the viewpoints of economic feasibility, technical feasibility, environmental impact, social aspects and also prioritization by Sri Lanka side.

152. The Weras Ganga basin is adjacent to the Greater Colombo area and most of the basin has been urbanized. It is also expected to be highly developed in the future. The Weras Ganga basin presently has flood damage to be mitigated and will have a large flood damage potential in the future. There is an urgent need for the storm water drainage project for the Weras Ganga Basin. It is reasonable to carry out the feasibility study for the Weras Ganga storm water drainage project.

Recommendations

153. *Topographic Maps*: In the master plan study, only topographic maps of 1: 50,000 and 1: 10,000 were available. The contour line intervals in those maps are 5 to 10 m and they are insufficient to accurately demarcate the storm water retention areas in the lowland areas (less than 2 m above MSL) which are important measures in the proposed storm water drainage plan. The detailed topographic maps for the feasibility study should have contour lines of less than 1 m intervals in the lowland areas to be proposed as a storm water retention area.

154. *Planning Scale*: No planning scale guideline for storm water drainage has been prepared yet in Sri Lanka. For the present Study, the guideline used in Japan was referred to. The planning scale is one of the fundamental subjects to determine a policy of flood control for the future and it should be decided by the government in compliance with various administrative issues in the country. The Study recommends applying the planning scale of a 50-year return period considering the importance of the study area in the Colombo Metropolitan Region, but optional planning scales of 25-year and 10-year return periods were also studied. Based on the study result, the guideline for storm water drainage and flood control planning scales should be prepared as early as possible to carry out consistent storm water drainage and flood control works.

155. *Target Year*: The socio-economic framework for the storm water drainage planning was set based on the Colombo Metropolitan Regional Structure Plan (CMRSP)

prepared by UDA in May, 1998. The target year of CMRSP is 2010. The proposed storm water drainage plans were prepared based on the above framework, but the proposed projects will be implemented beyond 2010 because of the huge project costs. Therefore, it should be understood that the proposed plans aim first at realization of CMRSP and only secondarily at completing all the proposed projects.

156. *Storm Water Retention Area*: In the Study, the minimum required retention areas for the proposed storm water drainage plan were proposed for each objective basin mostly in the lowlands. In addition, there exist lowlands extending outside of the proposed retention areas, which also function as a natural storm water retention area. From the viewpoint of storm water drainage, the proposed retention areas have to be conserved since it is closely related to the scale of the proposed storm water drainage facilities such as river channels. On the other hand, the lowlands extending outside the proposed retention areas are not taken into account in the proposed storm water plan, but those lowlands should be conserved as much as possible as they contribute to mitigation of flood damages.

157. *Execution of Non-structural Measures, etc.*: From the viewpoint of a comprehensive storm water drainage plan, non-structural measures for the storm water drainage are proposed in addition to the structural measures. Further, in order to achieve sustainability of the proposed storm water drainage projects, an institutional development plan, O&M plan and human resources development plan were proposed in the Study. It is recommended to actualize those proposals.

158. *Water Quality Improvement*: The proposed storm water drainage plans include storm water retention areas. The retention areas such as marshes and abandoned paddy lands will receive the wastewater from the densely populated areas during flood and the wastewater may cause a negative impact on the ecology of the lowlands designated as a storm water retention area. In addition, the stagnation of pollutants in the drainage canals during non-flood periods will accelerate the water quality deterioration process. It causes extraordinary growth of water plants such as water hyacinth, etc. and this results in the blocking of storm water passage in many places in the drainage canals. Treatment of the wastewater should be considered in conjunction with the storm water drainage project.

159. *Future Land Use Patterns*: In the future land use patterns forecast in the Study, the Ja Ela and Bolgoda basins (except Weras Ganga sub-basin) are assumed to remain almost unchanged because no land use plan and no development plan are available so far. The proposed storm water drainage plan should be reviewed if and when a substantial land use change was expected or concrete development plans were prepared as these events will change the flood runoff conditions.

PART III: FEASIBILITY STUDY

12. BACKGROUND OF PRIORITY PROJECT

Priority Project for the Feasibility Study

160. The storm water drainage project for the Weras Ganga basin (the Project) located in the northern part of the Bolgoda basin was selected as a priority project subject to a feasibility study after totally evaluating the storm water drainage plans for the four objective basins from the viewpoints of economic viability, technical viability, environmental aspects, social aspects and also prioritization by Sri Lanka side. The storm water drainage plan proposed in the master plan consists of 7 schemes shown in Figure 4.13. The schemes to be subject to feasibility study are selected among the said 7 schemes based on economic viability and urgency of the Project.

Implementation Policy of Strom Water Drainage Projects in Sri Lanka

161. A national storm water drainage policy for Sri Lanka has not yet been established. Also, prioritization of storm water drainage project implementation by river and area has not been made yet. The storm water drainage projects have been implemented based on needs at present. Considering the overwhelming importance of CMR in the national economy, the storm water drainage projects will be implemented focusing on CMR for the coming decade. The highest priority of storm water drainage improvement may be given to the Colombo District, which has the largest population and the highest population density in the country. It means that the proposed Weras Ganga basin storm water drainage project also may have the highest priority in implementation.

Storm Water Drainage Projects in CMR

162. The substantial storm water drainage projects implemented in the past, currently under implementation and to be implemented are listed as follows:

1) Greater Colombo basin:
   - GCFC&EIP Phase I and II
2) Weras Ganga basin (Southeast of Greater Colombo):
   - GCFC&EIP Phase III
   - Weras Ganga Basin Storm Water Drainage Project proposed in the Study
3) Lunawa Lake basin (South of Greater Colombo):
   - Lunawa Lake Environmental Improvement and Community Development Project

163. It can be said that the storm water drainage project for the entire Weras Ganga basin was started by the GCFC&EIP Phase III. The proposed Project is therefore recognized as a second phase of the entire Weras Ganga Basin Storm Water Drainage Plan. It is

recommended to carry out the proposed Project following the GCFC&EIP Phase III from the viewpoint of consistency of storm water drainage in the Weras Ganga Basin.

Need for Proposed Project

164. The development of the Weras Ganga basin will progress not only in the lowlands but also in the entire basin. The urbanization of the basin will cause an increase in flood runoff and the flood runoff increase will result in an increase in the flood damage in the lower areas. The storm water drainage plan should be a basin-wide plan taking into account the conditions of the entire basin. Especially, a question of the advisability for filling of lowlands is being discussed without any substantial engineering study on the required extent of retention area or the impact of the loss of retention area. The present Study will identify the required storm water retention area and implementation of the proposed Project will result in conservation of the proposed storm water retention areas.

165. The proposed Weras Ganga basin storm water drainage project aims not only at flood damage reduction in the basin, but also conservation of the lowlands, which function as a storm water retention area taking into account the future development of the basin. It is essential that the storm water drainage project should precede the basin development to preclude serious storm water drainage problems. The implementation of the storm water drainage project will assure the sound and easy development of the basin.

166. The proposed Weras Ganga Basin Storm Water Drainage Project will include conservation of the storm water retention area. It will result in conservation of the lowlands and impart a positive impact to the environment. Also, the proposed Project can contribute to poverty reduction through improvement of the living conditions of the people affected by the Project as they are mostly classified into the low-income group. The need for the proposed Project can be confirmed based on the above considerations.

13. PRESENT CONDITIONS IN THE WERAS GANGA BASIN

13.1 Natural Conditions

Geography

167. The Weras Ganga basin (feasibility study area) is situated in the south-eastern outskirts of Colombo and a sub-catchment of the Bolgoda basin as shown in Location Map. It extends approximately between lat. 6°47´N and lat. 6°53´N and between long.

79°52´E and long. 79°58´E. The catchment area at Kospalana bridge near Moratuwa University is 55.5 km^2, which corresponds to 14.2 % of the Bolgoda basin.

168. The Weras Ganga is generally flat and characterized by lowlands extending along the Weras Ganga main stream and the downstream stretches of tributaries as shown in Figure 4.9. The lowland area below the elevation of 3 m above MSL occupies 25% of the Weras Ganga basin. The lowland extending around Bellanwila and Attidiya, including the abandoned paddies, is called " Bellanwilla-Attidiya Marsh". On the other hand, the highest elevation is observed at the watershed boundary of Maha Ela sub-basin, which is 35 m above MSL. The elevations of highlands in other sub-basins range from 20 to 30 m above MSL.

Climate

169. The Weras Ganga basin is situated within the low country wet zone and has a tropical monsoonal climate. Mean annual temperature is approximately 27℃, with mean maximum and minimum temperatures of 30℃ and 24℃, respectively. Average annual rainfall in the Weras Ganga basin is 2,500 mm at the Ratmalana meteorological station. The monthly average rainfall ranges between about 70 mm and about 400 mm. Three types of rainfall patterns are distinguished in the Weras Ganga basin, that is, monsoon rains, convectional rains and depressional rains. Humidity varies from 70% during the day to 90-95% at night.

13.2 Socio-economic Status

Overview

170. The Weras Ganga basin (feasibility study area) is characterized as one of the fastest growing areas in Colombo Metropolitan Region (CMR) and is strategically important for the development of CMR. The northwestern part of the Weras Ganga basin is designated as a Core Area in the CMR Structure Plan prepared by UDA. The population is highly concentrated and large scale urban development is expected.

171. The Weras Ganga basin plays an important role as a center of the economic and social activities and in provision of housing for the people of CMR. The western part of the basin is a center of industrial and commercial activities, while the eastern part of the basin is characterized mainly by residential areas and the potential for residential development is high due to urban sprawl phenomena from Colombo and migration from the other areas of Sri Lanka.

Population

172. The population of the Weras Ganga basin in 2001 was estimated at 382,000 which accounts for 7.1% of the population of CMR (5,356,000) and 2% of the population of

Sri Lanka (19 million, Central Bank estimates). The population growth rate of the Weras Ganga basin is 2.1%, which is higher than that of CMR, which was 1.7% in 1990s. Moratuwa MC and Kewbewa PS show high growth rates of 2.9% and 2.3%, respectively.

173. Average population density in the Weras Ganga basin is estimated to be 69 persons per ha, which is higher than the Colombo District average of 51 persons per ha. The population density of Dehiwala - Mount Lavinia MC and Moratuwa MC on the western part of the basin come to 132 persons/ha and 106 persons/ha, respectively. On the other hand, Maharagama UC and Kesbewa PS on the eastern part have lower densities of 52 persons/ha and 69 persons/ha, respectively.

Economic Conditions

174. GRDP of the Weras Ganga basin is estimated from GRDP for the Western Province, employment for Colombo District, population allocation and economic activities in the basin. It is approximately Rs. 36.3 billion or 7.5% of GRDP of CMR. The manufacturing sector has the highest share with 31.5% of GRDP followed by commercial/hotel & restaurant sector with 29.4%. The agricultural sector is limited to 1.1%. Per capita GRDP of the Weras Ganga basin is estimated at Rs.95,100, which is higher than the national average of Rs. 64,900.

175. Monthly household income of Colombo District is the highest in Sri Lanka with Rs. 11,100, and the Western Province average is Rs. 9,200. They are higher than the national average of Rs. 6,500. Since the Weras Ganga basin belongs to Colombo District and the economy is active, the average monthly income level is therefore expected to be between Rs. 9,200 and Rs. 11,100.

176. With the Samurdhi program, a subsidy is paid to families with monthly household incomes of less than Rs. 1,500. The amount of subsidy, which ranges from Rs. 140 to Rs. 1,000, is determined by the number of family members. The poverty conditions of the Weras Ganga basin are relatively better than the condition in the country as a whole, but worse than Colombo District. The percentage of households receiving social welfare in the Weras Ganga basin is estimated at 13.3 % which is lower than the national average of 39.1%, but higher than the Colombo District average of 12.0%.

13.3 Present Land Use

177. The present land use pattern of the Weras Ganga basin was analyzed based on the aerial photos with a scale of 1: 8,000 shot in 2000 and 2001 and topographic maps with a scale of 1: 2,000 prepared in March 2002. Figure 13.1 shows the present land use pattern of the Weras Ganga basin. About 80 % of the basin is urbanized and 20% by

natural/rural use. Among the land use categories, the homestead has the largest share at 27.9% and gardens with 25.3% follows.

178. Spatial land use patterns in the Weras Ganga basin are characterized by landform or elevation. In the low-lying areas under the elevation of 5 m, paddy, grassland and marsh are dominant categories. The grassland is observed on the micro-relief. It could be regarded as abandoned paddy. On the other hand, residential areas are well-developed in the upland area relatively free from flood inundation. Some of them are being created by clearance of the coconut forests.

13.4 Environment

Social Environment

179. According to the inventory survey of the households (1,539 households) to be affected by the proposed storm water drainage project carried out in the Study, the average number of household members of the surveyed households is 4.2 persons/household. The main occupation of household heads is laborer followed by unemployed. The religion of the majority is Buddhist. Other religions are much less prevalent. Among the surveyed households, 49% are in the low-income group with a monthly income of less than Rs. 5,000. Further,those under the poverty line (Rs. 3,000/month) come to 21%.

Natural Environment

180. *Waste Disposal:* Waste disposal to drainage canals and lowlands is one of the major environmental issues since it obstructs the storm water flow and decreases the retention effect of the lowlands. The waste disposal is undertaken mainly by open dumping under the responsibility of the relevant local authorities. Most of the dumping sites are located in lowlands such as marshy areas and abandoned paddy fields and are creating a water pollution problem due to polluted leachate from the dumping site entering into the water bodies including the drainage canal system.

181. *Marsh Area:* After the paddy cultivation activities were abandoned in the 1970s, the Bellanwila-Attidiya marsh area located in the center of the Weras Ganga basin has been re-colonized by diverse vegetation which provides habitats for a great variety of wildlife. After several research investigations on ecological conditions of the marsh area by NGOs, the marsh area (372 ha) was declared as a Wildlife Sanctuary under the Flora and Fauna Protection Ordinance (FFPO) in 1990. However, a total lack of appropriate management for conservation, wastewater inflow and solid waste dumping has gradually deteriorated the natural environment of the Sanctuary.

182. *Surface Water Pollution*: Surface water pollution in the canals and marshes is a serious problem in the Weras Ganga basin. The main causes of surface water pollution are direct discharge of domestic and industrial wastewater, uncontrolled and illegal dumping of industrial and domestic wastes and discharge of sewage. Regarding the domestic wastewater, only some part of Dehiwala - Mount Lavinia MC area is covered by a piped sewerage system established in early 1900s. The Weras Ganga basin is not covered by a sewerage system.

13.5 Storm Water Drainage

Drainage Systems

183. The Weras Ganga basin selected for feasibility study is defined as a drainage area upstream of the Kospalana bridge on the Moratuwa-Piliyandala Road across, which crosses the Weras Ganga from west to east as shown in Figure 4.9. The extent of the drainage area is 55.5 km^2. The Weras Ganga basin is broadly divided into the following seven sub-basins.

Sub-basin	Area (km^2)
Nugegoda-Rattanapiya	8.2
Bolgoda Canal	7.7
Boralesgamuwa North	4.9
Boralesgamuwa South	4.0
Maha Ela	20.4
Ratmalana-Moratuwa	8.1
Thumbowila	2.2
Total	55.5

Flood Prone Areas and Flood Damage

184. The flood damage survey under the GCFC&EIP Phase II in 1995 identified 75 locations of flood prone areas in Dehiwala - Mount Lavinia MC and Moratuwa MC. Of those, 30 locations were located within the Weras Ganga basin. The other survey carried out in 2001 during the Study identified 39 locations of flood prone areas in the Weras Ganga basin. Locations of the flood prone areas mentioned above are shown in Figure 13.2.

185. According to the results of interviews in the flood prone areas under the 2001 flood damage survey, frequency of inundation is 5.2 times a year with duration of 1.1-day on average as shown below. It is suggested that flooding in the Weras Ganga basin is characterized by frequent occurrences even in the case of normal rainstorm event.

Sub-basin	Frequency (times/year)	Duration (days)
Nugetoda-Rattanapitiya	4.4	0.8
Bolgoda Canal	6.1	1.0
Boralesgamuwa North	4.5	1.2
Boralesgamewa South	2.8	1.6
Maha Ela	3.9	2.0
Ratmalana-Moratuwa	7.0	1.0
Thumbowila	(N/A)	(N/A)
Weras Ganga Basin	5.2	1.1

186. Based on the results of the inundation analysis and assessment of direct and indirect damages, the amount of annual damage under the present condition is estimated at Rs. 253 million/year for the entire Weras Ganga basin as shown below. On the other hand, the flood damage survey in 1995 estimated an annual flood damage of Rs. 118 million/year in total for Dehiwala - Mount Lavinia MC and Moratuwa MC areas.

Sub-basin	Estimated Extent of Inundation Area by Return Period (ha)					Annual Damage (million Rs.)
	2-year	5-year	10-year	25-year	50-year	
Nugetoda-Rattanapitiya	99	118	128	142	150	31
Bolgoda Canal	114	140	147	159	162	85
Boralesgamuwa North	85	95	102	109	121	9
Boralesgamewa South	60	76	81	87	91	5
Maha Ela	272	331	367	405	431	26
Ratmalana-Moratuwa	77	93	104	115	121	95
Thumbowila	16	21	23	26	27	2
Weras Ganga Basin	721	873	952	1,042	1,101	253

Causes of Flooding

187. The outstanding problems attributed to the present storm water drainage system of the Weras Ganga basin are broadly classified as follows.

Problems	Affected Areas
Flooding of Weras Ganga	Low-lying areas along the Weras Ganga right bank from Kandawala to Telewala in the Ratmalana-Moratuwa sub-basin
Obstruction of storm water drainage by reduction of flow capacity in the downstream end of the major tributary connecting to the Weras Ganga	Downstream reaches of Bolgoda Canal, Rattanapitiya Ela, Depawa Ela and Maha Ela,
Overflow from major tributary due to insufficient flow capacity of channel or crossing structure for storm water runoff	Middle and upstream reaches of Nugegoda, Ela, Delkanda Ela, Depawa Ela, Maha Ela
Drainage difficulty due to absence of channel construction or improvement for storm water drainage	Middle and upstream reaches of Nugegoda, Ela, Delkanda Ela, Depawa Ela, Boralesgamuwa South
Drainage difficulty in low-lying areas with ground elevation of 1.0m above MSL or less, backed up by Weras Ganga water level	Low-lying areas along the Weras Ganga right bank from Kandawala to Telewala in Ratmalana-Moratuwa sub-basin

188. The causes of the above problems are uncontrolled urbanization, encroachment of low-lying areas of Weras Ganga, runoff increase resulting from urbanization, uncoordinated construction and improvement of drainage facilities and lack of maintenance of drainage facilities.

14. HYDROLOGICAL ANALYSIS

Rainfall Analysis

189. Based on the daily rainfall data of 3 rainfall gauging stations in the Weras Ganga basin, which are operated by the Department of Meteorology, the probable basin maximum 24 hr rainfall for return periods from 2 to 50 years is analyzed. Also, the probable 60-minute rainfall is analyzed based on the short duration rainfall record of the Colombo rainfall gauging station. The results are as follows:

Return Period (years)	Probable Maximum 24 hr Rainfall (mm)	Probable Maximum 60-minute Rainfall (mm)
2	137	66
5	175	80
10	201	89
25	234	101
50	258	109

190. The rainfall pattern is determined based on the record of Colombo rainfall stations with short duration data. The duration of rainfall in the Weras Ganga basin is mostly less than one day and one rainfall event will have two to three heavy rainfall peaks. Among the rainfall events studied, the rainfall event that occurred in April 1999 is selected as a prototype design rainfall pattern with a duration of one day. The design rainfall has a peak of the probable 60-min rainfall.

Flood Runoff Analysis

191. The runoff analysis was carried out by using the same software (MIKE11) as the master plan study. The objective basin is divided into 187 sub-catchments with areas of less than 1 km^2 and 110 branches (channels or water paths) for the flood runoff calculation.

192. The probable peak runoff discharges calculated under present and future conditions at 1) Bolgoda canal at Elawella road, 2) Maha Ela outfall and 3) Weras Ganga outfall are summarized in the table below. Due to the insufficient flow capacity of Maha Ela at the Colombo-Piliyandala Road Bridge, the flood runoffs at Maha Ela outfall are very small considering the size of Maha Ela basin.

Return Period (years)	Bolgoda canal at Elawella Road (20.8 km^2)		Maha Ela outfall (20.4 km^2)		Weras Ganga outfall (55.5 km^2)	
	Present (m^3/sec)	Future (m^3/sec)	Present (m^3/sec)	Future (m^3/sec)	Present (m^3/sec)	Future (m^3/sec)
2	19.5	25.5	7.9	11.0	48.3	52.0
5	26.9	35.2	10.6	14.7	60.6	69.9
10	33.0	42.7	12.6	17.2	69.8	82.4
25	40.4	53.8	15.3	20.3	83.6	99.0
50	46.0	62.7	17.3	22.4	94.0	112.9

15. PRIORITY PROJECT

15.1 Socio-economic Framework for Planning

Population Framework

193. Population framework is set based on the development strategy in the CMR Structure Plan (CMRSP). The urban population growth rate estimated in the CMRSP is 2.4%. Basic strategy for population planning is to reduce the population density pressure in Colombo by diverting the population to growth centers and newly emerging urban areas surrounding the existing urban areas. The proposed population density in the CMRSP is 120 persons/ha for the Core Area, and 300 persons/ha for high density areas.

194. Based on the basic assumptions and projected population density of the Weras Ganga basin, the total population of the Weras Ganga basin in 2010 is estimated at 483,000, which is 1.26 times larger than the 2001 level. The population density comes to 87 persons/ha.

DS Divisions	Population (2001)	Projected Population (2010)	Estimated Annual Increase Rate (%)
Dehiwela - Mount Lavinia	48,000	57,000	1.88
Ratmalana	69,000	83,000	1.88
Moratuwa	48,000	60,000	2.38
Sri Jayawardana Kotte	30,000	39,000	2.68
Maharagama	54,000	71,000	2.68
Kesbewa	134,000	173,000	2.87
Weras Ganga basin	382,000	483,000	2.37

Economic Framework

195. The economic framework of the Weras Ganga basin is set based on the following conditions:

1) GRDP growth rate of the Weras Ganga basin is estimated to be 8.4% up to 2005 and 9.5% from 2006 to 2010.
2) Agricultural activity will decrease.

3) Manufacturing will be still one of the major economic activities.
4) Commercial activities and tourism will be developed.
5) Housing development will be accelerated.

196. Based on the above conditions, GRDP of the Weras Ganga basin as an economic framework is estimated as follows:

Sector	Growth Rate (2001-05) (%)	Growth Rate (2006-10) (%)	GRDP (2010) (Rs. million)	Sector Share (%)
Agriculture	1.6	1.6	480	0.6
Industry	6.3	7.0	27,340	31.8
Service	9.9	10.9	58,030	67.6
Weras Ganga Basin	8.4	9.5	85,850	100.0

15.2 Future Land Use Pattern

197. The future land use pattern of the Weras Ganga basin was forecast by spatial trends of urbanization, future land use proposals and development plans, and development factors and limiting factors. The future land use proposals and development projects (Figure 15.1) taken into account are as follows:

1) Zoning plan prepared by UDA in 1991 (draft),
2) Master plan for low-lying areas prepared by UDA in 1996
3) Bellanwila-Attidiya Wildlife Sanctuary
4) Ratmalana Airport Extension Project,
5) Police Academy Project
6) Boralesgamuwa Theme Park Project
7) Baseline Road Extension Project

198. Figure 15.2 shows the future land use pattern of the Weras Ganga basin. The share of urbanized area is estimated at 83%, which does not change significantly compared with present land use. This is because the natural/rural use areas such as paddy, marsh, vegetation and water are limited and no area change is expected. However, a large change is forecast in the urbanized use. The share of homesteads will grow from 28% to 50%, while that of gardens will decrease from 25% to 9%.

15.3 Component Schemes of the Priority Project

199. For the selection of the priority schemes for the feasibility study, each scheme proposed in the master plan study is economically evaluated as follows:

Scheme	Project Cost (million Rs.)	Annual Benefit (million Rs.)	B/C	EIRR (%)
(1) Nugegoda-Rattanapitiya	1,316	204	1.75	16.1
(2) Bolgoda Canal	458	87	2.08	17.9
(3) Boralesgamuwa North	279	44	1.74	16.1
(4) Boralesgamuwa South	137	17	1.45	13.8
(5) Maha Ela	626	121	2.16	18.7
(6) Ratmalana-Moratuwa	1,299	213	1.95	16.9
(7) Weras Ganga Scheme	986	98	1.21	10.9

200. Considering the economic evaluation result and the urgent necessity of the scheme based on the present flood damage situation, the following four schemes shown in Figure 15.3 were selected to be combined as a priority scheme. The proposed Weras Ganga Basin Storm Water Drainage Project consists of those four schemes.

1) Weras Ganga Scheme
2) Nugegoda-Rattanapitiya Scheme
3) Bolgoda Canal Scheme
4) Ratmalana-Moratuwa Scheme (Urban Drainage Improvement in Kandawala and Telawala areas)

15.4 Structural Measures

Weras Ganga Scheme

201. The Weras Ganga Scheme shown in Figure 15.4 is envisaged to alleviate direct flood damage in the densely urbanized lowland on the right bank of the Weras Ganga and to increase the flow capacity of the main stream as well as improve drainage capacity of the principal drainage channels such as Bolgoda Canal and Rattanapitiya Ela connecting to the Weras Ganga. The structural measures of the Weras Ganga Scheme are proposed as follows:

1) Conservation of two major storm water retention areas, i.e., Weras Ganga Swamp Retention Area (65 ha) and Maha Ela Marsh and Lowland Retention Area (106 ha)
2) Dredging of the riverbed of the Weras Ganga (length 5,500 m and width 19 - 40 m)
3) Construction of flood protection dikes for the densely urbanized lowland in the Kandawala - Telawala area on the right bank of the Weras Ganga (length 2,300 m)

202. The design bed for dredging is level at 1.5 m below MSL in consideration of the bed level of the North Bolgoda Lake. Dredging width is designed as 40 m on the basis of the present opening width at the Kospalana bridge. The stretch around the Borupana bridge is subject to a water level rise with increase of storm water runoff after improvement of the Bolgoda Canal and dredging of the upper Weras Ganga. The

channel width is taken as around 70 to 80 m to lower the water level upstream of the Borupana bridge and minimize the water level rise downstream.

203. The flood protection dike is made of wet masonry wall instead of earth embankment dike to minimize the required width of land in consideration of the present built-up condition along the right bank. The height of the proposed flood protection dike is around 1 m. The proposed dike has an attached promenade and drainage canal. The total required width for construction comes to 7 m.

Nuegoda-Rattanapitiya Scheme

204. The Nugegoda-Rattanapitiya sub-basin shown in Figure 15.5 is located in the northern part of the Weras Ganga basin and has already been highly urbanized. Inundation takes place not only the Rattanapitiya Ela in the lower reaches but also the Nugegoda Ela and Delkanda Ela in the middle and upper reaches. The Rattanapilitya is affected by backwater from the Bolgoda Canal in the Bellanwila-Attidia marsh area.

205. The Delkanda Ela downstream of the High Level Road becomes narrow due to restriction by houses. The Nugegoda Ela faces inconsistency in the channel alignment in upper reaches and inadequate flow capacity, as well as obstruction by under-sized crossings in the unimproved lower reaches. The structural measures for alleviating the problems above are proposed as follows:

1) Channel improvement of Rattanapitiya Ela (length 2,130 m)
2) Channel improvement of Delkanda Ela (length 1,760 m)
3) Channel improvement of Nugegoda Ela (length 1,580 m)
4) Conservation of retention areas in the middle reaches, i.e., Upper Nugegoda Ela Retention Area, Lower Nugegoda Ela Retention Area and Delkanda Ela Retention Area (total extent 36 ha)

206. The Delkanda Ela needs to be much wider compared with the existing width. However, the right bank of the reaches is mostly occupied by the shoulder of the Old Kesbewa Road and the left bank is also restricted by middle-class houses in places. As the widening of these reaches is rather difficult in due to the necessity for relocation of the houses, it is proposed to divert and connect the Delkanda Ela with Nugegoda Ela just upstream of the Suriyamal Mawatta in the lowland. Consequently, a new confluence is to be located around 600 m upstream from the existing confluence.

Bolgoda Canal Scheme

207. The downstream reaches of the Bolgoda Canal to the Weras Ganga shown in Figure 15.6 are completely filled up with water plants and do not function as a drainage channel. For augmentation of storm water drainage capacity in the Bolgoda Canal sub-basin as well as the Nugegoda-Rattanapitiya sub-basin, the downstream reaches of

the Bolgoda Canal should be restored. The structural measures for the Bolgoda Canal sub-basin are proposed as follows:

1) Channel improvement of Bolgoda Canal lower reaches (length 2,400 m)
2) Conservation of Bellanwila-Attidiya Marsh Retention Area (88 ha)

208. In the vicinity of the Bolgoda Canal, the extension plan of the Ratmalana Airport runway is under consideration. Together with the land filling for extension of the runway, construction of a diversion channel is envisaged along the edge of the land fill area for connection to the Weras Ganga swamp. This diversion is incorporated in the Bolgoda Canal Scheme. The channel improvement comprises removal of water plants, excavation/dredging, and provision of a maintenance road. The design bed elevation is set at 1.5 m below MSL.

Ratmalana-Moratuwa Scheme

209. Besides the direct influence from the Weras Ganga flooding, the highly urbanized area along the Weras Ganga right bank from Kandawala to Telewala shown in Figure 15.7 is prone to storm water drainage congestion because of the low-lying topography. The subject area covers the drainage area between the Galle Road and Weras Ganga with an extent of 3.3 km^2.

210. The proposed urban drainage improvement aims at alleviating drainage congestion in the lowland with a ground elevation of 1 m or less above MSL along the Weras Ganga and local drainage problems taking place frequently at higher locations. The structural measures for the Ratmalana-Moratuwa sub-basin are proposed as follows:

1) Improvement of the main canals discharging storm water runoff into the Weras Ganga (length 3,580 m)
2) Improvement of secondary canals leading storm water runoff into the main canals or retention ponds (length 6,390 m)
3) Provision of storm water retention ponds at the downstream ends of the main canals (2 locations)
4) Construction of flood protection dikes on the right bank of Weras Ganga (length 1,150 m)

The total length of urban drainage improvement is 11,120 m, together with two storm water retention ponds in Kandawala and Telewala (water surface area 3 ha and 10 ha, respectively).

Physical Measures for Conservation of Retention Area

211. The proposed minimum required storm water retention areas need to be conserved by legislative restriction for land use.

1) Upper Nugegoda Ela Retention Area, Lower Nugegoda Ela Retention Area and Delkanda Ela Retention Area (total extent 36 ha)
2) Weras Ganga Swamp Retention Area (65 ha) and Maha Ela Marsh Retention Area (106 ha)
3) Bellanwila-Attidiya Marsh Retention Area (88 ha)

212. In addition, physical measures are also required to make the land use restriction effective by means of clear delimitation of the boundary of the retention area. A periphery canal is proposed along the boundary of the retention area, together with a promenade and vegetation. The total length of the required periphery canals comes to about 20 km.

15.5 Non-structural Measures

213. In order to supplement the structural measures or make them sustainable, non-structural measures are proposed. The non-structural measures proposed for the Weras Ganga basin are as follows:

1) Storm water retention area management
2) Development control in urban development areas
3) Land use regulation in lowland areas
4) Dissemination of flood information to the public
5) Flood-proofing of buildings in flood-prone areas

These measures are the same as those proposed in the master plan.

214. *Storm Water Retention Area Management*: The role of the storm water retention area is very important from the technical and economic viewpoints in the Weras Ganga basin. Therefore, the proposed storm water retention areas (295 ha) should be conserved properly by taking the following measures.

1) Legal designation of storm water retention areas
2) Regulation of land use in storm water retention areas
3) Strict legal action for illegal activities

215. *Development Control in Urban Development Areas*: The Weras Ganga basin is expected to be highly urbanized in the future because of its location adjacent to the city of Colombo. Urbanization of the basin causes an increase in flood runoff. However, it may be inevitable to implement development projects in the future. To cope with this, it is proposed to require all developers, including the government agencies in charge of urban development, construct flood retarding ponds, rainwater storage facilities and seepage facilities to reduce the flood runoff from the development areas. The enactment of regulations making their construction mandatory is proposed.

216. *Land Use Regulation in Lowlands*: The houses affected by storm water inundation are mostly located in the lowlands which are originally flood-prone areas. The people living in the lowlands along the Weras Ganga are affected by the high water level of the Weras Ganga. To stop recurrence of this situation, it is proposed to regulate the land use in the lowland areas so as to stop dwelling in the flood-prone area.

217. *Flood-proofing of Buildings in Flood-prone Areas*: In principle, it is better to relocate the houses in the flood-prone areas such as marshes and natural flood retention areas to mitigate the flood damages. However, if it is decided to continue dwelling in the flood-prone areas, flood-proofing of the buildings (houses) should be introduced, such as raising of the foundation ground, introduction of piloti type buildings, wall-fencing around the houses and waterproof buildings.

218. *Dissemination of Flood Information*: To properly conserve the retention areas, various information such as relevant regulations, prohibited activities, boundaries of the retention areas, etc. should be disseminated to the public to get their understanding and awareness for the flood control measures. Further, it also will be effective for mitigation of the flood damage to disseminate information on flooding condition of the residential areas and lowlands to the public. Based on the information disseminated, the people may avoid dwelling in the areas with flood risk such as lowlands and also learn how to cope with floods.

16. PRELIMINARY DESIGN

Design Criteria

219. The preliminary design was carried out for the structures proposed for each scheme such as river channels, dikes, revetments, bridges, sluiceways, culverts, retention ponds and peripheral canals for the retention areas. The criteria for the preliminary design were established referring to the Manual for River Works in Japan, Government Ordinance on Structural Standards for River Management Facilities, etc. of Japan, Geometric Design of Roads of Sri Lanka and the Bridge Design Manual of Sri Lanka.

Weras Ganga Scheme

220. The Weras Ganga Scheme shown in Figure 15.4 includes channel dredging, construction of flood protection dikes, storm water retention ponds and sluiceways. The channel dredging of the Weras Ganga is designed with the following dimensions:

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bed Width
Weras Ganga	5.5 km	79 - 164 m^3/s	-1.5 m MSL (Level)	Trapezoidal	19 - 40 m

The alignment for dredging is mostly set along the present channel alignment. The dredging reaches are extended into Bolgoda Lake North for 1.2 km from Kospalana Bridge.

221. The flood protection dike for the Kandawala-Telawala area on the right bank of the Weras Ganga is designed as a wet masonry type. The length of the dike is 2,300 m and the dike top is set at 1.1 to 1.4 m above MSL (about 1 m above ground surface). Sluiceways for inland drainage equipped with flap gates are provided at three locations. Their dimensions are as follows:

Location	Size (BxH)	Quantity
Kandawala	2.0 m x 1.9 m	2
Telawala North	2.5 m x 1.9 m	2
Telawala North	2.5 m x 1.9 m	2

Nugegoda-Rattanapitiya Scheme

222. In the Nugegoda-Rattanapitiya Scheme shown in Figure 15.5, the Rattanapitiya Ela, Nugegoda Ela (right tributary) and Delkanda Ela (left tributary) are to be improved. The channel alignment of each river is set along the present channel alignment in principle. The channel profiles and sections are designed with the following dimensions.

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bed Width
Rattanapitiya	2.13 km	25 - 53 m^3/s	1/1,200 - 1/800	Rectangular, Trapezoidal	19 m
Delkanda	1.76 km	14 - 29 m^3/s	1/300 - 1/700	Rectangular, Trapezoidal	3-13.5 m
Nugegoda	1.58 km	10 - 24 m^3/s	1/450 - 1/700	Rectangular, Trapezoidal	5-13 m

223. In the densely populated area, the channel cross section is designed as a rectangular shape with gabion revetment to minimize house relocation. The total length of the rectangular section comes to 3,360 m. There are 14 bridges and one culvert to be replaced. A maintenance road of 4 m width is arranged on either side of the channel. The length is 3,910 m in total.

Bolgoda Canal Scheme

224. In the Bolgoda Canal Scheme is shown in Figure 15.6. The channel improvement of Bolgoda Canal is designed with the following dimensions.

Channel	Length	Design Discharge	Longitudinal Profile	Channel Shape	Bed Width
Bolgoda Canal	2.4 km	23 - 51 m^3/s	-1.5 m MSL (Level)	Trapezoidal	15 - 19 m

The channel alignment is mostly set along the present channel alignment, but the downstream reaches around Ratmalana Airport are shifted to the left bank side so as to cope with the Ratmalana Airport Runway Extension Plan. A maintenance road of 4 m width is provided on one side of the channel. The length is 2,600 m in total.

Ratmalana-Moratuwa Scheme

225. In the Ratmalana-Moratuwa Scheme shown in Figure 14.7, major drains along roads and open channels are to be improved. Considering the limited space for construction, a type of concrete flume with cover is adopted for the drains along the roads to effectively use the open space on the concrete flume after construction. The total length of concrete flume is 6,390 m and the size (B × H) of concrete flume ranges from 0.8 m × 0.8 m to 2.0 m × 1.5 m. The existing open channels are widened to have dimensions of 1.0 m × 1.0 m to 6.0 m × 1.5 m. The total length of open channel to be improved comes to 3,580 m.

226. In addition, an open channel with wet masonry revetment is provided along the flood protection dike of the Weras Ganga. The total length of the drainage channel is 1,150 m and the size (B × H) is 1.0 m × 1.0 m to 1.5 m × 1.0 m. At the ends of the drainage system, retention ponds are provided at Kandawala and Telawala to temporarily retard storm water. The pond area is 3 ha at Kandawara and 10 ha at Telawala (3 ponds). The bottom elevation of the ponds is set at 1.0 m below MSL. The pond water is discharged through the sluiceways to be constructed in the Weras Ganga Scheme.

17. INSTITUTIONAL ARRANGEMENT

Institutional Arrangement for project Implementation

227. As shown in Figure 17.1, SLLRDC will be appointed as an executing agency for the proposed Project under supervision of the Ministry of Housing & Plantation Infrastructure (MHPI). In addition, the Inter-Agency Steering Committee (IASC), Utility Diversion Committee (UDC) and HCDC Coordination Committee (HCC) are organized in order to make the project implementation smooth.

228. Within SLLRDC, the Canal Development & Maintenance Division (CDM) is appointed as the primary responsible division for the overall project implementation as shown in Figure 17.2. CDM supervises all project works to be implemented in the project with the consultant team. Other divisions will assist CDM in the relevant fields.

229. IASC is organized to provide a guideline for the project implementation, to discuss and solve the major problems and critical constraints encountered during the project implementation and also to monitor and evaluate the project progress. IASC is chaired

by the Secretary of MHPI and will consist of the members representing relevant agencies such as MHPLG, UDA, NHDA, CEA, local authorities, SLLRDC, etc.

230. UDC is established to discuss technical issues on relocation and installation of utility facilities in the project area. UDC includes representatives of the utility agencies concerned, that is, NWSDB, CEB, SLTL and local authorities. UDC is chaired by the Chairman of SLLRDC.

231. A Housing and Community Development Committee (HCDC) is established in five local authorities in the project area to hear opinions and requests of the people in the project area. HCDC will play an important role in supporting the project implementation in each local authority, especially the activities related to land acquisition and resettlement. In order to coordinate among HCDCs, and further, to construct a close relationship between the executing agency and the local communities, the HCDC Coordination Committee (HCC) is established. HCC is chaired by the Chairman of SLLRDC.

Institutional Arrangement of Relevant Local Authorities

232. The project area belongs to the administrative areas of five local authorities, that is, Dehiwala - Mount Lavinia MC (DMMC), Moratuwa MC (MMC), Kotte MC (KMC), Mahalagama UC (MUC) and Kesbewa PS (KPS). Among them, DMMC, MMC and MUC have already established an HCDC, which is chaired by the Mayor or Chairman with coordination from the Community Development Officer (CDO).

233. Kesbewa PS has not established an HCDC yet. One CDO was dispatched by the Commission of Local Government, Western Provincial Council and is working for community related works with some staff. It is recommended to establish HCDC by initiative of CDO and start the activities before commencement of the Project.

Financial Status of SLLRDC and Local Authorities Concerned

234. The overall financial status of SLLRDC is at a sound level. The turnover in 2000 is Rs. 276 million and operating expense Rs. 186 million. However, the interest from fixed deposits represents a high share of the turnover, 47% of the turnover on an average from 1996 to 2000. However, this interest from fixed deposits can not be used for O&M of the drainage canals. The only fund source for the O&M works is the budget allocated from the central government at present. It is important for SLLRDC to make due arrangement to acquire the budget for O&M works. The subcontracting works from local authorities and other entities have been increasing steadily from Rs. 16 million in 1996 to Rs. 43 million in 2000, which indicates that the O&M activity has been strengthened.

235. The financial statuses of five local authorities relevant to the Project are summarized below.

Item	DMMC	MMC	KMC	MUC	KPS
Revenue (million Rs./yr., 1996-2000)	256	166	151	51	69
Recurring Expenditures (million Rs./yr. in 2000)	230	147	121	40	46
Personnel employment	61.9%	45.7%	57.0%	49.8%	35.4%
Maintenance of assets	5.2%	21.3%	7.9%	20.7%	21.2%
Transportation, communication utility & other services	12.6%	15.5%	13.0%	13.3%	20.3%
Supplies & requisite	11.4%	10.6%	10.5%	7.7%	13.2%
Independent Revenue Rate	49.7%	46.5%	45.7%	51.6%	40.4%
Grant Revenue Rate in Revenue	54.2%	59.0%	56.7%	58.0%	74.0%

The financial structures of the relevant five local authorities heavily depend on the grant revenues from the central and local governments. For the sustainable O&M of the storm water drainage facilities to be constructed by the Project, financial strengthening of the relevant local authorities is essential.

18. OPERATION AND MAINTENANCE PLAN

Organization for O&M

236. The organizations responsible for O&M of the drainage facilities to be constructed by the Project are SLLRDC, D Dehiwala - Mount Lavinia MC, Moratuwa MC, Kotte MC, Maharagama UC and Kesbewa PS. However, it is proposed that SLLRDC should be responsible for O&M of the major parts of the Project taking into account the O&M work capacities of the relevant local authorities and their relationship with lowland management. Meanwhile, the local authorities should be responsible for O&M of the urban drainage systems in the respective administrative areas.

O&M Work Demarcation

237. The proposed Project is composed of four schemes, the Weras Ganga, Nugegoda-Rattanapitiya, Bolgoda Canal and Ratmalana-Motrtauwa schemes. It is proposed that the substantial O&M works for the Weras Ganga, Nugegoda-Rattanapitiya and Bolgoda Canal Schemes are undertaken by SLLRDC, while the O&M works for the Ratmalana-Motrtauwa Scheme are undertaken by Dehiwala - Mount Lavinia MC (DMMC) and Moratuwa MC (MMC). Other local authorities are requested to assist SLLRDC's O&M activity by periodical inspection of the drainage facilities located in the respective administrative areas. The demarcation of the O&M works is illustrated in Figure 18.1.

Operation and Maintenance Work Plan

238. In SLLRDC, the Canal Maintenance Section of the Canal Development & Maintenance Division (CDM) is the section responsible for the O&M works. The actual works are proposed to be handled by the existing Attidiya Regional Office from the view point of easy access to the work sites and the existing task allocation. In addition, a new urban drainage section in the Kirimandara Mawatha Regional Office proposed in the master plan is requested to handle the on-the job training and lectures for staff of the local authorities. To cope with the above tasks, the Attidiya Regional Office and Kirimandara Mawatha Regional Office have to strengthen their staffing.

239. DMMC and MMC should establish a separate section in the Municipal Engineers Department so as to undertake the O&M related activities by themselves after taking over the drainage facilities constructed by the Project. On the other hand, Kotte MC and Kesbewa PS may keep the existing organizational structure for the time being as only periodical inspection of the drainage facilities is requested. DMMC and MMC should carry out a stepped staff arrangement.

240. The O&M equipment is one of the major resources for the sustainable O&M activities over the long term. The responsible organizations should procure the equipment required for the O&M works. Also, it is proposed to carry out the stock control of the spare parts and tools under the management of a responsible section to meet the demand at any time.

Staff Training Program for SLLRDC and Local Authorities

241. For sustainable O&M works, it is proposed to prepare and execute training programs for the staff of SLLRDC and local authorities in charge of O&M works. One is an O&M Management Program. It aims at developing the management capability of managerial and engineering staff. The main subjects are overview of management principles and planning and programming know-how for O&M works. The other is an O&M Equipment Operation Program. It aims at training technical staff, work supervisors and machine operators. The main subjects are understanding of the mechanism of O&M equipment and how to achieve the operational knowledge and experience.

19. ENVIRONMENTAL IMPACT ASSESSMENT

242. *Conceivable Impacts*: Based on the environmental screening and scoping for the proposed schemes, the environmental impact is examined for resettlement by land acquisition and relocation of religious/public facilities, temporary traffic disturbance during construction, breeding places for mosquitoes in the proposed retention ponds, flora & fauna in the Bellanwila-Attidiya Wildlife Sanctuary, emission gas and dust

during construction, noise and vibration during construction, and offensive odor by disposal of dredged material and removed aquatic weed. Most of the impacts are mitigated by using appropriate construction methods and machinery/equipment, but some impacts should be addressed as mentioned below.

243. *Social Environment*: The important social environment to be considered is land acquisition and resettlement. No critical social constraints which hamper the proposed Project are expected so far. The number of households to be resettled for the proposed Project is estimated at 158 according to the "Inventory Survey on Households to be Resettled" conducted in the study. Compensation and necessary assistance on the resettlement should be provided to both legal and illegal occupants to be resettled under the National Involuntary Resettlement Policy. A resettlement plan is proposed in the subsequent chapter.

244. *Bellanwila-Attidiya Wildlife Sanctuary*: The Bellanwila-Attidiya Wildlife Sanctuary is largely included in the proposed storm water retention area, so that it is recommended to acquire all the proposed retention area for conservation. As a result, the Bellanwila-Attidiya Wildlife Sanctuary can be conserved. The dredging of the Weras Ganga and demolition of the saline water intrusion protection gates on the Bolgoda Canal would cause a certain rise in salinity level of the channels in the Sanctuary during non-flood periods. However, most of the vegetation in the Sanctuary would not be affected drastically because most of the sanctuary area is not submerged during non-flood periods. It could be said that the dredging and demolition of the gates return the sanctuary area to the natural condition as it previously existed .

245. *Dredged Materials*: Dredging of the Weras Ganga and Bolgoda Canal is to be conducted under the proposed Project. The dredged materials contain organic matter. The dredging volume is estimated at around 140,000 m^3. In addition, some of the materials excavated for channel improvement also contain organic matter. An offensive odor is expected if the dredged materials are disposed of by open dumping without any measures. Therefore, the dredged materials should be immediately transported to the designated temporary dumping site or final disposal site keeping a certain distance from residential areas. The candidate sites are shown in Figure 19.1.

246. *Aquatic Weeds*: Disposal of aquatic weeds is also a potential issue as well as disposal of the dredged materials. Many places of the Weras Ganga and canals in the lowlands are covered by floating, submerged and bottom-rooted vegetation. Extraordinary growth of these aquatic weeds caused by the water quality deterioration in the canal blocks storm water passage. The aquatic weeds have to be removed. To reduce the volume to be disposed and avoid public complaint on the disposal of the aquatic weeds,

it is recommended to consider utilization of the removed aquatic weeds for biogas generation and composting by digestion facilities.

247. *Monitoring*: In the construction and operational stages of the proposed Project, the environmental mitigation measures mentioned above should be properly taken. SLLRDC will be primarily responsible to consider the environmental management although the environmental mitigation measures should be taken by the contractor, local authorities, and/or relevant agencies. To confirm the effectiveness of the mitigation measures and compliance with the environmental requirements and any environmental incidentals, environmental monitoring should be conducted by the relevant agencies and SLLRDC.

20. RESETTLEMENT PLAN

Basic Information

248. *Resettlement and Land Acquisition*: Based on topographic maps with a scale of 1: 2,000 and results of the "Inventory Survey on Households to be Resettled", the number of households to be resettled is estimated at 158. Most of the houses are located in the Weras Ganga scheme area (36 houses) and Nugegoda-Rattanapitiya scheme area (98 houses). The land area to be acquired for the proposed Project is estimated at 31 ha in total not counting the storm water retention area of 295 ha.

249. *Acceptance of Resettlement*: According to the inventory survey, a half (50%) of the households to be resettled answered that the resettlement can be fully accepted or accepted with some conditions. Regarding the resettlement site, 39 % of the households to be resettled prefer resettlement sites near the present residences and 7.4 % will accept any location, but 54.1% withheld an answer to the inventory survey.

250. *Income Level:* According to the inventory survey, almost half (49%) of the households to be benefited by the Project (158 households) are classified into the low-income group of which monthly income is less than Rs. 5,000 and 42% of them are under poverty line with a monthly income of Rs. 3,000 or less. The proposed Project could have a poverty reduction aspect through improving the living conditions of the people in the project area.

Responsible Organizations

251. The organizations responsible for resettlement for the proposed Project are SLLRDC (Executing Agency), the relevant five local authorities and the National Housing Development Authority (NHDA). In SLLRDC, the Canal Development & Maintenance Division (CDM) is in charge of the land acquisition and resettlement

with assistance of NHDA. CDM is responsible for preparation and implementation of the Resettlement Action Plan under the Sri Lanka National Involuntary Resettlement Policy (NIRP). For the resettlement, the relevant local authorities undertake official procedures and activities related to the resettlement by direct communication with the households to be resettled. In each local authority, a Housing and Community Development Committee (HCDC) is organized to resolve social issues related to resettlement. On the other hand, SLLRDC will establish an HCDC coordination committee to coordinate the activities of the HCDCs of the five local authorities related to the project.

Assistance for Resettlement

252. *Resettlement Action Plan:* Based on the Sri Lanka National Involuntary Resettlement Policy (NIRP), a comprehensive Resettlement Action Plan (RAP) has to be prepared for the proposed project as 20 or more families are affected by the Project. The resettlement assistances planned in the RAP such as consultation on seeking a resettlement site, employment matters and arrangement for moving to the resettlement site should be monitored and the countermeasures, when necessary, should be executed promptly to implement the resettlement smoothly.

253. *Livelihood Recovery*: The households to be resettled need to recover their livelihood after the resettlement, to at least the same as the previous livelihood level. The condition of the livelihood recovery of the households to be resettled should be monitored regularly after the resettlement. In the case where the livelihood recovery for the household is not going well, additional assistance by the Project should be provided promptly. In addition, unexpected incidence and/or grievance from the households affected should be taken care of through monitoring.

254. *Resettlement Site*: The households to be resettled are generally scattered except those of the Delkanda Ela area. The resettlement sites will be selected near the present residence based on consultations with each household under assistance of HCDC, NHDA and SLLRDC. On the other hand, it may be difficult to acquire resettlement sites near the present residences in the Delkanda Ela area where the building density is high and the number of households to be resettled is relatively large (60 households). Therefore, a resettlement site with an area of about one ha should be prepared for the people of the Delkanda Ela area. The candidate location is shown in Figure 20.1.

Public Involvement

255. *Public Explanation*: In the latter stages of the proposed Project, a public explanation meeting on the proposed Project and the induced resettlement should be held for the households affected as early as possible. In addition, consultation with the households

to be resettled should be conducted by the relevant organizations such as local authorities, NHDA and SLLRDC. RAP should be elaborated to meet the demands of the households affected. Thus, the public involvement in the project implementation should be undertaken as soon as possible.

256. *Community Contract*: The community contract system was introduced as a new approach for community development under the Million Houses Program in the 1980s. Under the system, the communities registered as a Community Development Council (CDC) are eligible for the contract. The contracted works are implemented by the communities designated under supervision of NHDA. Regarding the proposed Project, it is recommended to apply the community contract system for a small part of the project construction works to involve the relevant communities in the Project, allocate a part of project profit to the community and also enhance the public awareness of the necessity of the proposed storm water drainage project.

257. *Employment in Construction Works:* The community contract is one of the measures for public involvement in the Project. In addition to the community contract, it is proposed to establish a system to employ the people affected by the Project as laborers as much as possible, taking into account the low-income level of the households affected by the Project.

21. CONSTRUCTION PLAN AND COST ESTIMATE

Construction Period

258. The construction period of each scheme is estimated below. The overall construction period of the proposed Weras Ganga Basin Storm Water Drainage Project comes to 36 months. The overall construction schedule is shown in Figure 23.1.

1) Weras Ganga Scheme : 21 months
2) Bolgoda Canal Scheme : 19 months
3) Nugegoda-Rattanapitiya Scheme : 32 months
4) Ratmalana-Moratuwa Scheme : 31 months

Mode of Construction

259. It is proposed to divide the proposed project works into two packages of main civil works and procurement of O&M equipment taking into account the sort of work. The selection of the contractors for both packages will be made through international competitive bidding. The contractors to be selected should have an adequate capability to successfully execute the scheduled works and extensive experience in international business.

Cost Estimate

260. The cost items and exchange rate for the cost estimate are the same as those applied for the master plan mentioned in Part I. The costs are estimated based on the preliminary design. The estimated project cost is given below.

Cost Item	Amount (million Rs.)
1) Construction cost	1,907
2) Land acquisition and compensation cost	841
3) Procurement of O&M equipment	113
4) Engineering services cost	381
5) Administration cost	63
7) Price escalation	88
8) Physical contingency	303
9) Tax	693
Total	4,389

261. The cost of annual O&M for the channel, other civil structures and storm water retention areas is estimated at Rs. 40 million. This corresponds to about 2% of the construction cost.

22. PROJECT EVALUATION

Economic Evaluation

262. The economic viability of the Project is evaluated in the same manner as applied to the master plan study in Part I. The project life is taken as 40 years and the discount rate as 10%. The B-C, B/C and EIRR are calculated as follows:

(Unit: million Rs.)

Extent of Retention Area	Project Cost	Annual Flood Reduction Benefit	Annual Land Enhancement Benefit	B-C (million Rs.)	B/C	EIRR (%)
295 ha	4,389	147	875	3,043	2.09	18.8

The result indicates that the proposed Project is economically viable since the B/C is more than 1.0 and EIRR more than 10%.

263. Sensitivity analysis was conducted for the following cases to analyze the effect of a decrease in the project benefit and/or increase of the project cost.

Case	B-C (million Rs.)	B/C	EIRR (%)
Base Case	3,043	2.09	18.8
Case 1: Decrease of benefit by 10%	2,459	1.88	17.2
Case 2: Increase of cost by 10%	2,764	1.90	17.4
Case 3: Combination of Case 1 and Case 2	2,180	1.71	16.0

It is confirmed that the proposed project has sufficient economic viability for the above cost increase and benefit decrease.

Qualitative Benefits

264. In addition to the quantitative benefit, the proposed storm water drainage project is expected to yield the following qualitative benefits.

1) Recreational development
2) Housing development
3) Promotion of economic development
4) Improvement of people's living conditions
5) Reduction of inconvenience in people's lives
6) Improvement of the hygienic environment
7) Elimination of the menace of flooding
8) Improvement of the water environment
9) Contribution to poverty reduction

265. According to the inventory survey on households affected by the proposed project conducted in the Study, the number of the households with monthly incomes of less than Rs. 5,000 comes to about 750 households or 49% of the households surveyed (1,539 households) and the share of households with monthly incomes under the poverty line (less than Rs. 3,000/month) is 21%. These people are recognized as beneficiaries of the proposed project. The improvement of their living conditions by the Project will consequently contribute to poverty reduction.

Technical Evaluation

266. The proposed project includes dredging, channel excavation, construction of dikes, revetments, bridges, culverts and sluiceways. No constraints for implementation of the Project are found from the technical viewpoint such as design, construction and O&M since no special technology is needed for the construction and O&M work. All the construction works can be done by Sri Lanka contractors, which have the proper technical qualifications although participation of international contractors in bidding for the Project is expected to employ a capable contractor.

Environmental Evaluation

267. On the whole, environmental impacts potentially caused by the proposed project can be avoided or mitigated by appropriate mitigation measures. Among the potential environmental impact items, the resettlement for the Project is the most significant issue to be carefully treated, but no critical factor that could hamper the resettlement has been identified so far.

268. The ecological impact to the Bellanwila-Attidiya Wildlife Sanctuary can be mitigated by conservation of the proposed storm water retention area as the Sanctuary is mostly covered by the retention area. The dredging of the Weras Ganga and demolition of the saline water intrusion protection gates on the Bolgoda Canal may slightly increase the salinity level of the Weras Ganga and Bolgoda canal, but it will not cause any serious impact as, in the long term, the original environment would be reinstated to the same condition as it was in the past.

Social Evaluation

269. The number of households to be resettled for the Project is 158 in total. No critical factor, which hampers the resettlement, has been identified as long as the compensation and necessary assistance on the resettlement are properly made under the National Involuntary Resettlement Policy.

270. The proposed project will mitigate the flood damages to the people affected by flood and improve their living environment. In the Weras Ganga basin, a relatively large number of the low-income people reside along the river channel to be improved. Those people will be benefited by the proposed project. The proposed project also can create an employment opportunity for the people living in the project area such as direct employment in the construction and/or indirect employment through the community contract system.

Overall Evaluations

271. It is concluded that there is sufficient need for the proposed Weras Ganga Basin Storm Water Drainage Project to justify its implementation and that it is economically, technically, environmentally and socially viable. The proposed project primarily aims at reducing the flood damages in the Weras Ganga basin, but it will produce various tangible and intangible benefits. Also, the proposed project will improve the people's living conditions and consequently contribute to poverty reduction.

23. PROJECT IMPLEMENTATION PLAN

272. The proposed organization for implementation of the Weras Ganga Basin Storm Water Drainage Project (the Project) is shown in Figure 17.1. The Sri Lanka Land Reclamation & Development Corporation (SLLRDC) is assigned as the executing agency for the Project. The Ministry of Housing and Plantation Infrastructure (MHPI) will supervise SLLRDC through the Inter-Agency Steering Committee.

273. The Project is planned to be implemented over 6 years as shown in Figure 23.1. The implementation period is largely divided into the detailed design stage,

pre-construction stage and construction stage. The detailed design stage including investigation and tender document preparation will be implemented over 22 months, the pre-construction stage for procurement of contractors for 12 months and the construction stage for 38 months.

274. The project cost is estimated at Rs. 4,389 million. Considering the present severe financial condition of Sri Lanka Government, it is proposed to procure a soft loan for the Project from the international funding agencies. The loan amount will come to Rs. 2,792 million excluding land acquisition and compensation cost, administration cost and tax which will be not eligible for a loan. The Sri Lanka Government has to bear the remaining cost of Rs. 1,597 million.

24. CONCLUSION AND RECOMMENDATIONS ON THE FEASIBILITY STUDY

Conclusion

275. The proposed Weras Ganga Basin Storm Water Drainage Project is economically and technically viable and there are no serious environmental or social problems that hamper implementation of the proposed project. It is concluded that the proposed project should be implemented.

276. The proposed project will contribute to poverty reduction through improvement of the people's living conditions. According to the household inventory survey carried out in the Study, half (49%) of the households to be benefited by the Project are classified into the low-income group of which monthly income is less than Rs. 5,000/month. 42% of them are under the poverty line with a monthly income of Rs. 3,000 or less. The proposed Project could improve their living conditions and consequently contribute to poverty reduction. Further, the Project may promote economic development in the project area and poverty will be indirectly alleviated by upgrading of the people's living standard through economic development.

Recommendations

277. *Conservation Policy of Bellanwila-Attidiya Wildlife Sanctuary*: The Bellanwila-Attidiya marsh area is expected to function as a storm water retention area in the proposed storm water drainage plan. It has been designated as a wildlife sanctuary (372 ha) including surrounding lowlands in 1990 and will be subject to conservation. However, the policy for conservation of the Bellanwila-Attidiya wildlife sanctuary has not been made clear by the responsible agency (Wildlife Conservation Department) so far. The policy to conserve the sanctuary should be discussed among the relevant government agencies and stakeholders and made clear as early as possible.

278. *Conservation of Storm Water Retention Areas*: In the proposed project, it is planned that the land making up all the proposed storm water retention areas (295 ha) be acquired to assure proper conservation and management. However, most of the proposed retention areas are private lands (abandoned paddy fields) and therefore it may be not so easy to acquire all the proposed retention areas. The method or measures to conserve the proposed retention areas should be determined as early as possible through discussion among the agencies concerned and the stakeholders.

279. *Saline Water Intrusion Protection Gates*: There exist six old gates (1.83 m × 1.83 m) for saline water intrusion protection on the Bolgoda Canal which is presently managed by Irrigation Department. The gates were constructed to protect the upstream paddy fields from saline water (already diluted). However, almost all the paddy fields have been abandoned. From the viewpoint of storm water drainage, it is better to demolish them (In the Study, the gates are tentatively planned to be demolished for smooth storm water flow.). The necessity of the gates should be discusses among the relevant government agencies as to whether they should be reserved or not.

280. *Resettlement*: According to the household inventory survey carried out in the Study, there are an estimated 158 households to be relocated and 50% may demand special conditions, the nature of which are uncertain at present, before they agree to move . For smooth resettlement, a public explanation on the proposed project and conditions for resettlement should be made by Executing Agency to the people affected by the Project immediately after implementation of the Project is officially decided in order to acquire their understanding and cooperation.

281. *Demarcation of Responsibilities*: As mentioned in the master plan study, demarcation of the responsibilities for the storm water drainage works in Sri Lanka is unclear at present. As the conservation of the storm water retention areas are essential for the storm water drainage plan, demarcation of responsibilities should be made clear as early as possible. It may be difficult to properly manage and conserve the proposed retention areas without clear demarcation of responsibilities among the relevant agencies. The lowland management should be made by a sole agency (SLLRDC) as proposed in the master plan.

282. *Water Quality Improvement*: The water of the Weras Ganga and major tributaries are contaminated by domestic and industrial wastewater from the surrounding urbanized areas. In the Study, the lowland of the Weras Ganga basin is designated as a storm water retention area and also most of the retention areas are covered by the Bellanwila-Attidiya Wildlife Sanctuary. In order to maintain better environmental conditions in the sanctuary and retention areas, a sewerage system in the urbanized and densely populated areas to treat the wastewater should be considered.

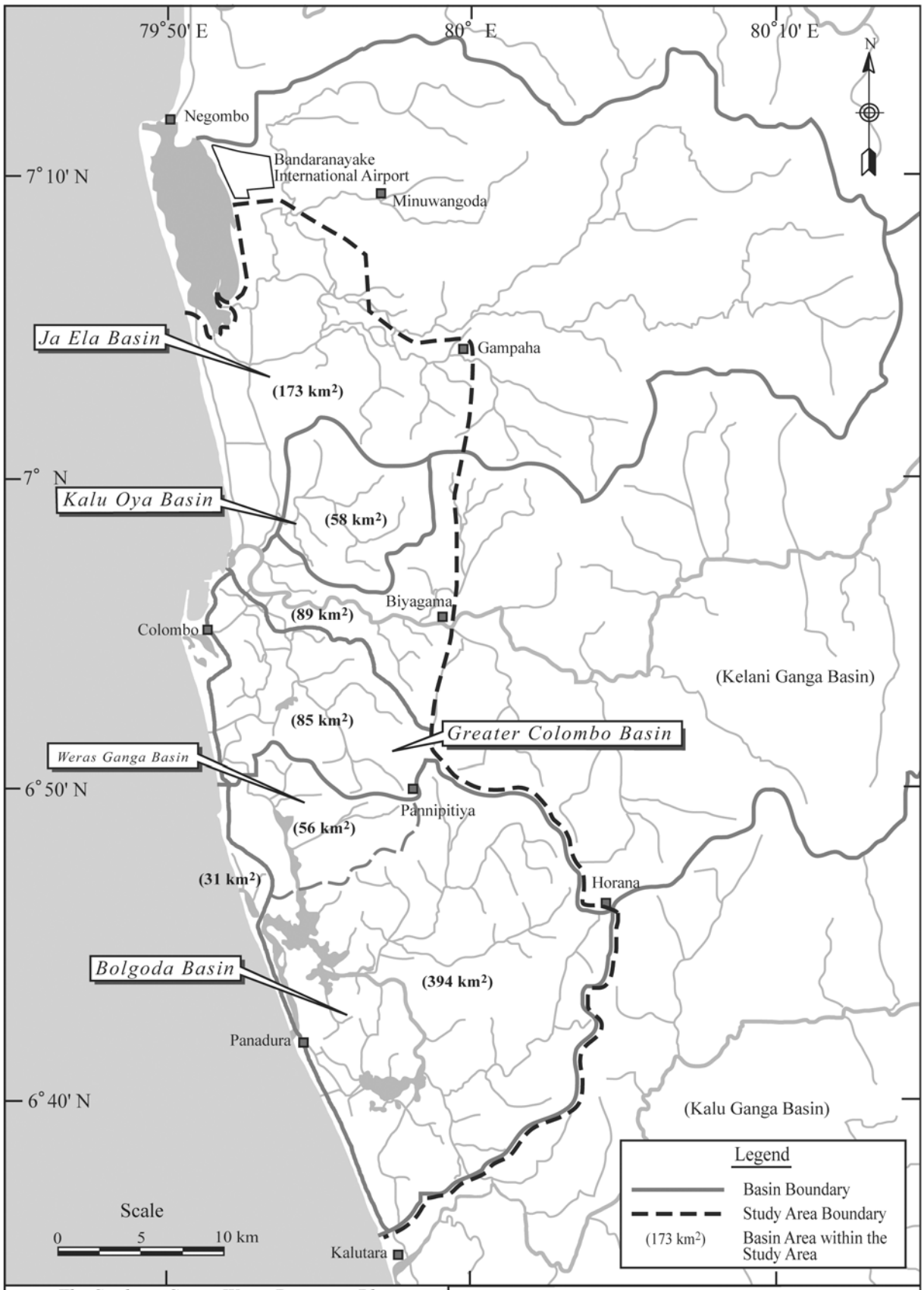
Tables

Table 10.1 Overall Evaluation for Selection of Priority Project

Component Project	Economic Viability		Project Cost	Technical Viability	Land Acquisition	Resettlement (household)	Poor Household Rate	Environmental Impact	Future Land Use of Area	Overall Evaluation
	B/C	EIRR								
1. Ja Ela Basin Storm Water Drainage Plan										
1) Ja Ela Channel Improvement 2) Dandugam Oya Channel Improvement 3) Storm Water Retention Areas	B (1.34)	B (12.9%)	B (3,679)	A	C+C (50 ha+ 876 ha*)	C (570**)	A (37%)	B	B (Semi Urban)	**C**
2. Kalu Oya Basin Storm Water Drainage Plan										
1) Kalu Oya Channel Improvement 2) Old Negombo Canal Improvement 3) Storm Water Retention Areas	A (1.94)	A (17.4%)	A (2,463)	A	C+B (30 ha+ 489 ha*)	C (730**)	A (37%)	B	A (Urban)	**B**
3. Greater Colombo Basin Storm Water Drainage Plan										
1) Madiwela South Diversion Canal 2) Restoration of Existing Mutwal Tunnel 3) New Mutwal Tunnel 4) Storm Water Retention Areas	A (2.23)	A (19.5%)	B (4,389)	A, B	C+B (25 ha+ 380 ha*)	C (1,050**)	B (24%)	B	A (Urban)	**B**
4. Bolgoda Basin Storm Water Drainage Plan (Weras Ganga Basin)										
1) Weras Ganga Scheme 2) Nugegoda-Rattanapitiya Scheme 3) Bolgoda Canal Scheme 4) Boralesgamuwa North Scheme 5) Boralesgamuwa South Scheme 6) Maha Ela Scheme 7) Ratmalana-Moratuwa Scheme	A (2.22)	A (19.2%)	C (5,102)	A	A+A (31 ha+ 295 ha*)	A (158)	A (35%)	A	A (Urban-Weras Ganga Basin)	**A**

Note: * area for storm water retention area, ** number of households living in riparian area

Figures



The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region in the Democratic Socialist Republic of Sri Lanka

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 1.1
Study Area and Relevant Drainage Basins

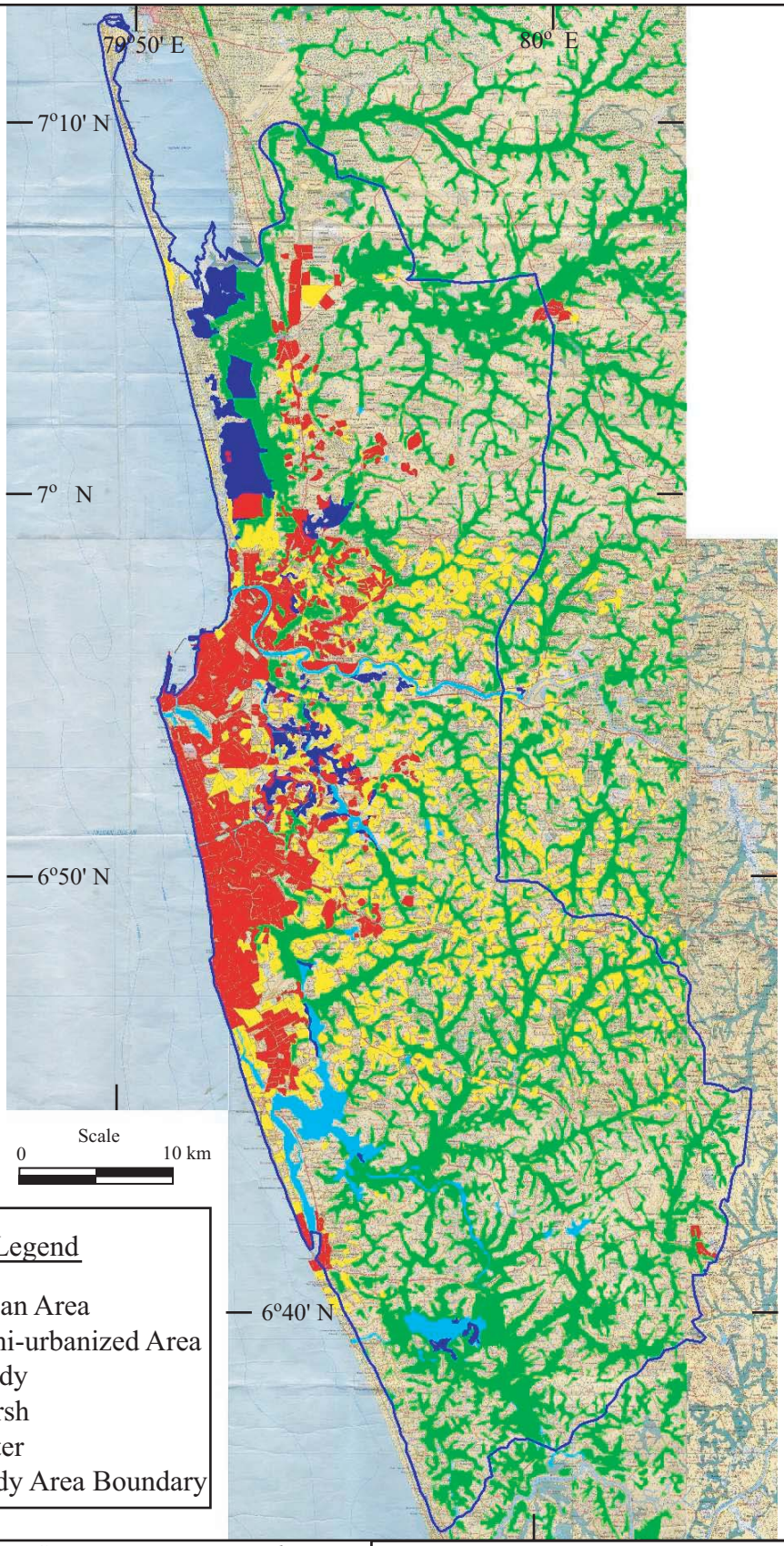


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Figure 2.1
Present Land Use Pattern in the Study Area

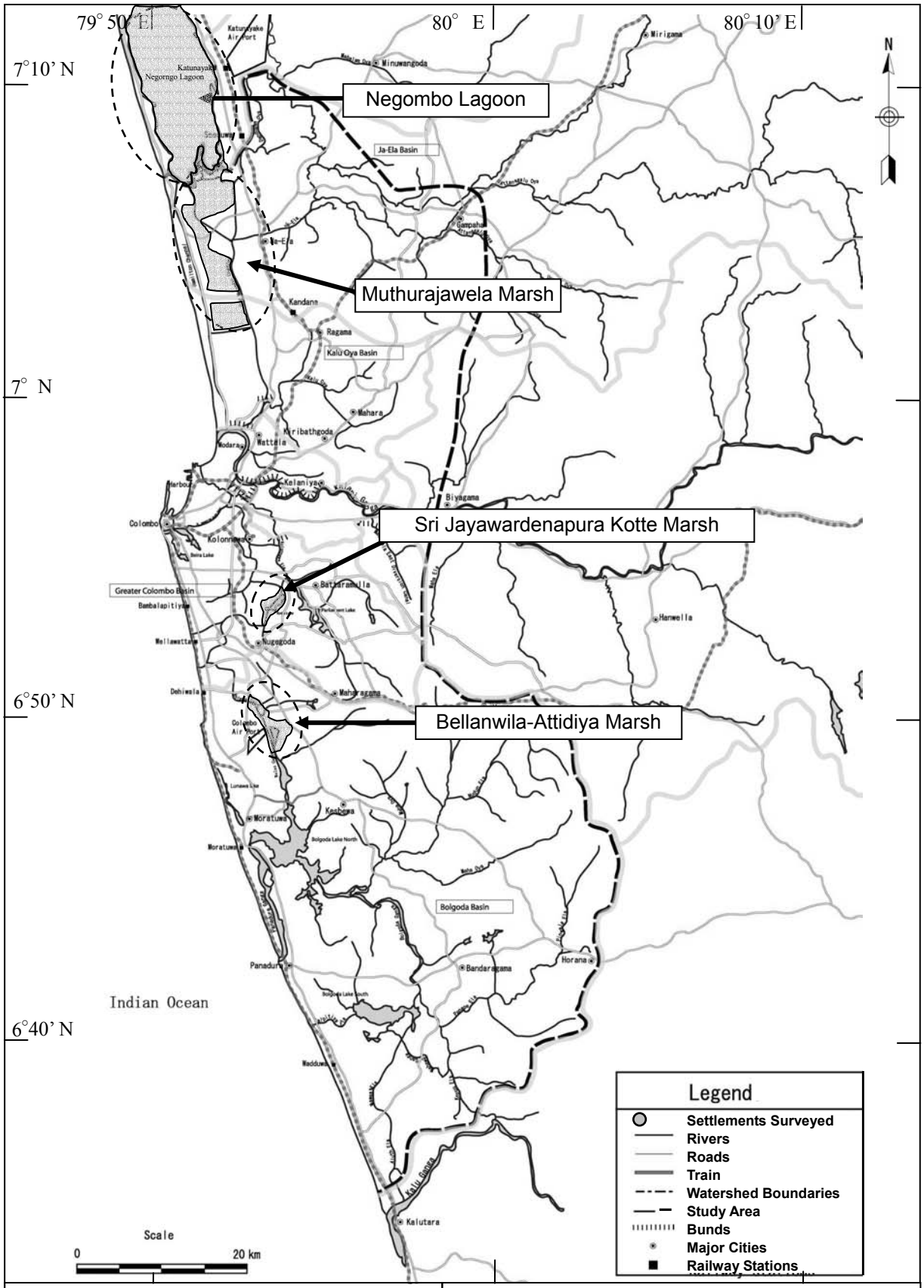

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Figure 2.2
Locations of Environmental Protected Areas